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XXXIV. *Experiments and Observations made in Britain, in order to obtain a Rule for measuring Heights with the Barometer.* By Colonel William Roy. F. R. S.

Read June 12 and 19, and Nov. 6 and 13, 1777.

I N T R O D U C T I O N.

IN philosophical inquiries of every kind, where any point is to be ascertained by experiments, these cannot be repeated too often, nor varied too much, in order to obtain the truth: for even when the utmost precaution hath been used, and the greatest pains have been taken, it rarely happens, that they agree so exactly, as to leave no room for doubt. Were it possible at all times, to have experiments made in circumstances perfectly similar, a considerable degree of consistency might naturally be expected among the results, whereof the mean would determine the point in question; but different men, making use of different instruments, have different modes of conducting their operations, each pursuing the tract that seems to him the most likely to insure success. Hence it is that a variety
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of results arise, and that things sometimes appear contradictory, or at least present themselves under new forms, difficult at first sight to be accounted for, and therefore apt to mislead, till by a farther investigation of the matter, the true causes are discovered. Even irregularities of this sort are worthy of being communicated, that others may know what hath happened before, and what, in like cases, they may expect to meet with, in the course of their future inquiries. Improvements of every kind advance by slow degrees; and it is not until things have been viewed in every possible light, that the errors, even of our own experiments, are discovered, the points in question ultimately ascertained, and the branch of philosophy depending upon them, gradually brought nearer to perfection.

Ever since the discovery made by TORRICELLI, the barometer hath been applied, by different persons, in different countries, to the measurement of vertical heights, with more or less success, according to the more or less perfect state of the instruments used, and the particular modes of calculation adopted, by the observers. But of all those who have hitherto employed themselves in this way, none hath bestowed so much time and pains, or succeeded so well, as Mr. DE LUC, of Geneva, F. R. S. In two quarto volumes, published some years since, that
gentleman

gentleman hath given us the history of the barometer and thermometer, with a very curious and elaborate detail of many years experiments, made by him, chiefly on the mountain Saleve. It would be totally superfluous here to enter into any circumstantial account of the method he makes use of, since that hath already been so fully illustrated by two Fellows of the Royal Society, who have at the same time given formulæ and tables, adapted to the measures of this country, (Phil. Trans. for 1774, vol. LXV. N° xx. and xxx.) that nothing farther can be desired on that head.

It may nevertheless be necessary just to call to remembrance that the rule, deduced from the observations on Saleve, consists of three parts. 1st, The equation for the expansion of the quicksilver in the tube, from the effect of heat, whereby the heights of the columns, in the inferior and superior barometers, are constantly reduced to what they would have been in the fixed temperature of $54^{\circ}\frac{1}{4}$ of FAHRENHEIT, independant of the pressure they respectively sustained. 2d, When the mean temperature of the column of air to be measured, is $69^{\circ}.32$, as indicated by thermometers exposed to the Sun's rays at its extremities; then the difference of the common logarithms, of the equated heights of quicksilver in the
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two barometers, gives the altitude intercepted between them, in toises and thousandth parts, reckoning the three figures to the right hand decimals, and the others integers, the index being neglected. This temperature of $69^{\circ}.32$, when the logarithmic differences give the real height without any equation, is reduced to $39^{\circ}.74$, the new zero of Mr. DE LUC's scale, when his formula is adapted to English fathoms and thousandth parts, instead of French toises. And lastly, when the mean temperature of the air is above or below $39^{\circ}.74$, an equation, amounting to $\frac{2.1}{10000}$ parts of the logarithmic height for each degree of difference, is, in the first case to be added to, and in the last subtracted from, that result, in order to obtain the real altitude.

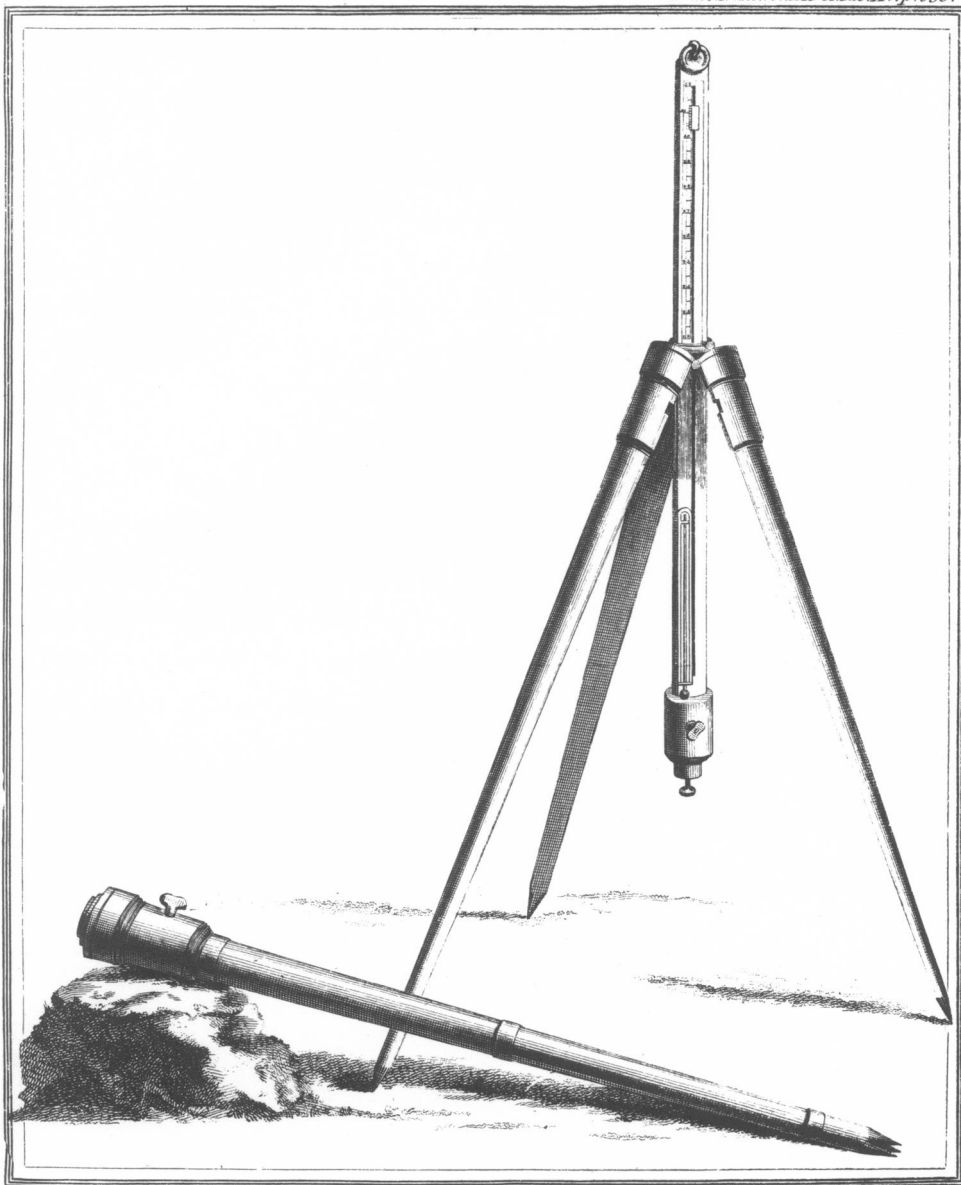
In Mr. DE LUC's book, the experiments for ascertaining the expansion of the quicksilver, are not given in detail; neither are the particular temperatures of the barometers specified. The winter season was however chosen for the purpose; one being left in a cold room, and the other in a closet, heated as high as could conveniently be suffered. The operation having been repeated several times without any essential difference in the results, this general conclusion is drawn, that between the temperatures of melting ice and boiling water, the expansion of
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the quicksilver is exactly six French lines, or .532875 decimal parts of an English inch. But it is to be observed, that the barometer stood then at 28.77525; whereas, if it had stood at 30 inches, it would have been .555556, because the expansion is in proportion to the length of the column. Farther, the interval between the freezing and boiling points in all thermometers, varies with the height of the barometer, or weight of the atmosphere; and it is the custom in England to make thermometers when the barometer stands at 30 inches; that is to say, 1.225 or 13.8 French lines, higher than when Mr. DE LUC's boiling point was fixed: and since from his experiments it appears, that each line of additional height in the barometer, raises the boiling point $\frac{1}{1134}$ th part of the interval between that and freezing, it follows that $\frac{180}{1134} = 0.158 \times 13.8 = 2^{\circ}.2$, will denote the number of degrees, that Mr. DE LUC's boiling point is lower than that of English thermometers, which reduces it to 209.8 of FAHRENHEIT, and makes the interval between freezing and boiling only 177.8 degrees. Hence the expansion .555556, formerly found, must be increased in the proportion of 177.8 to 180, which gives for the total .5624297 or .56243, on a difference of temperature of 180°. Thus the expansion for each degree, supposing it

to be arithmetical, or uniformly the same in all parts of the scale, will be .00312461^(a).

Having now shewn the expansion of quicksilver in the tubes of barometers resulting from the Geneva observations, I shall next proceed to give some account of those I made for that purpose. They derive their origin from my having very accidentally observed, that a small degree of heat, and of short duration, sensibly affected the length of the column in Mr. RAMSDEN's portable barometer, whereof a view is given in plate XVI. The principal parts of this instrument are a simple straight tube, fixed into a wooden cistern, which, for the convenience of carrying, is shut with an ivory screw, and, that being removed, is open when in use. Fronting this aperture is distinctly seen, the coincidence of the gage-mark, with a line on the rod of an ivory float, swimming on the surface of the quicksilver, which is raised or depressed by a brass screw at the bottom of the cistern. From this, as a fixed point, the height of the column is readily measured on the scale attached to the frame, always to $\frac{1}{500}$

(a) This paper having lately been communicated to Mr. DE LUC, he hath informed me, that the difference of temperature in his experiments, amounted to about 31° of REAUMUR, or 72° of FAHRENHEIT, above freezing: wherefore, $.00312461 \times 72 = .225$ nearly, will denote the rate of expansion from which he deduced that for 180°; and within these limits, it will hereafter be found to differ very little from the result of the present experiments.



part of an inch, by means of a nonius moved with rack-work. A thermometer is placed near the cistern, whose ball heretofore, was usually inclosed within the wood work, a defect that hath been since remedied. The three-legged stand, supporting the instrument when in use, serves as a case for it, when inverted and carried from place to place. Two of these barometers, after the quicksilver in them hath been carefully boiled, being suffered to remain long enough in the same situation, to acquire the same temperature, usually agree in height, or rarely differ from each other more than a few thousandth parts of an inch, which were constantly allowed for in calculating altitudes, as well as in estimating the rate of expansion, in the course of the following experiments.

S E C T I O N I.

Experiments on the expansion of quicksilver.

THE experiments made for this purpose were numerous as well as various, and were therefore subdivided into several classes. To give a minute detail of them all, would be extremely tedious, and now wholly useless, since it was from those of the third class alone, that the

rate as well as maximum of expansion was ascertained: wherefore those of the two preceding classes need only be mentioned in a general way.

The first set of the first class comprehended such as were made with one barometer in a cold room, or in the open air, and the other in a room on the same level with the former, where there was constantly a fire, which was occasionally increased, in order to augment the difference of temperature. When the heated barometer had remained several hours in an angle of the room, the difference of temperature of its quicksilver above that of the coldest, as indicated by their respective attached thermometers, rarely exceeded 10 or 12° , which, from a mean of many observations, gave an expansion of .0333 decimals of an inch, for the 10° comprehended between 32 and 42° of FAHRENHEIT'S thermometer. So far the result arising in this way, from small differences of temperature, will be found to agree with the third class of experiments.

But when, in the second set of this first class, the difference of temperature was augmented to 20 or 30° , by exposing the barometer within doors to a greater heat, or placing the superior one on the leads, whereby it received the direct and reflected rays of the Sun throughout the greatest part of the day, while the other was kept
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in the cold area underneath, the rate of expansion for the first 10° exceeded that formerly found nearly in the proportion of three to two, while that for the second and third terms, of 10° each, diminished progressively.

The chief, though not the only cause of this great difference, as will appear hereafter, arose from the position of the ball of the thermometer, originally inclosed within the wood-work of the frame, which prevented it from receiving the heat so readily as the quicksilver in the tube; at the same time that it retained it longer, and consequently produced results in some degree fallacious.

Finding, from the first class of experiments, that much uncertainty remained with regard to the rate of expansion of quicksilver affected by these smaller degrees of heat, and that it was utterly impossible, from them, to determine its maximum for the 180° between freezing and boiling; I resolved to try, how much a column of 30 inches of quicksilver, carefully boiled in a tube, would lengthen, the same being placed with the open end upwards in a tin vessel, occasionally filled with pounded ice and water, and afterwards brought to boil, by means of a charcoal fire placed underneath? In this second class, it was easy to see, that the expansion of the tube containing the quicksilver, was necessarily to be taken into the account, and added to that apparently found by experiment.

ment. This was of course to be done, either by such differences as I could discern and measure, or by those that had resulted from the experience of others.

The nature of the apparatus, employed in this class of experiments, will be easily understood from plate XVII. where it is represented, as it was used in those of the third class. In its first state it was not quite so long, and a chafing-dish with a charcoal fire, occupied the place of the cistern holding the quicksilver below. By means of a circular bit of tin, foldered edgeways in the center of the bottom, and an aperture in the middle of the lid, the tube was kept steadily in the axis of the vessel. Other openings in the lid, served for the admission of the thermometer, and the application of a deal rod close to the side of the tube, when its height was to be measured. The longitudinal expansion of the glass was marked by a scratch thereon with a fine edged file at the top of the deal rod, when respectively at the temperatures of freezing and boiling. The apparent dilatation of the quicksilver was in like manner marked, by the coincidence of its surface with the lower edge of a brass ring embracing the tube.

It having been found impossible to procure tubes whose bores were truly cylindrical, or of any uniform figure, the experiment was repeated, as often as possible,
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in both ends of the same tube, that the mean might be taken. But it frequently happened that the tube, which had undergone one or more experiments in one end, broke before any could be made with it in the other. In this case, the rate of expansion in the last end was taken from that given by such another tube, where it had succeeded in both. The mean of five results with the best tubes, taken in this way, gave .4901 for the apparent expansion of 30 inches of quicksilver, on 180° of FAHRENHEIT, between freezing and boiling, which being augmented by the apparent longitudinal dilatation of the glass $.0356 \times 3 = .1068$, the real expansion is .5969; exceeding Mr. DE LUC's by more than $\frac{3}{1000}$ ths of an inch. If, however, Mr. SMEATON's dilatation of glass, $(.025 \times 3 = .075)$ be substituted, instead of that resulting from these experiments, the real expansion of 30 inches of quicksilver will be .5651, which does not exceed it quite $\frac{3}{1000}$ parts of an inch.

In this class of experiments, having attended as diligently as possible to all the circumstances, it seemed to me, that tubes with a small bore, and whose glass was thick, lengthened more than those, which had a larger bore and whose glass was thin: whence I was led to suppose, that solid glass rods would dilate more in proportion, and consequently, shew a still more perceptible difference.

difference. With the view of ascertaining this point, I procured four glass rods near three feet long each, and of different diameters, the largest being of the size of the little finger, and the smallest about the thickness of a quill. One end of each, was somewhat larger than the other, and was made perfectly smooth, as that on which they were to rest when severally measured with the deal rod. They were then all placed in the tin vessel, in such a manner, as to admit pounded ice rammed very close around them, and the interstices to be filled with water. Having remained in that state a full half hour, they were severally measured with the deal rod, whose length of $32\frac{1}{2}$ inches was scratched on each with the sharp edge of the file. This being done, the ice thrown out, and the vessel carefully washed, all the rods were replaced in it, immersed in water, which afterwards was brought to boil. The fire being kept up, and the ebullition rendered as violent as possible for half an hour, the glass rods were then severally measured, by applying them one after another to the deal rod, standing with them in the boiling water. The experiment was repeated three times, on as many different days, without its being possible to discern, that any of the glass rods had dilated more than that of deal, from a difference of temperature of 180° . In all of them, the freezing mark seemed accurately to coincide with the top
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of the deal rod; whereas the dilatation of the tubes, by the same degree of heat, was always very visible^(b).

Finding from the second class of experiments, whereof the general result hath now been given, that glass rods seemed not to lengthen more than deal; and that tubes of different bores, and probably too of different sorts of glass, were susceptible of different degrees of extension, which rendered it impossible, by this means, to ascertain the longitudinal expansion of the quicksilver they contained; I thought it necessary to recur once more to the barometer, and to try whether it could not be so contrived as to act in water of different temperatures, from freezing to boiling. This led me to the experiments of the third class: and in order to comprehend them thoroughly, it seems necessary to point out some few alterations which the apparatus underwent.

The center of the bottom being pierced on purpose, a brass socket was prepared for it, wherein a hole was bored conically, to receive the ground-end of a barometer tube, of the ordinary length of $33\frac{1}{2}$ inches; the tube having been first ground in a separate piece of brass, and ulti-

(b) Since these experiments were made, the relative expansion of 18 inches of one of the tubes and one of the rods that had been formerly employed, was found to be, by Mr. CUMMING'S pyrometer, nearly as 4 to 1, from a heat approaching to that of boiling oil.

mately in the socket itself, fitted it so exactly, as to suffer no water to pass. The socket being inserted into the aperture at the bottom of the vessel, was firmly foldered to it for the reception of the tube, which was so ground as to reach a full inch and a half below the surface of the brass. It could not descend farther, the ground parts in both being of the figure of the frustum of an inverted cone. From the view in the plate it will appear, that underneath the vessel, a separate stand was placed, in order to support the iron cistern containing the quicksilver. The diameter of the cistern was such, that its stand being occasionally moved, so as to bring one side of it close to the ground part of the tube, the other side projected beyond the bottom of the vessel; and consequently permitted the rod of a float, resting on the surface of the quicksilver, to rise freely and parallel to the axis of the tube. The rod was of deal, $\frac{1}{10}$ th of an inch square, carrying on its top a scale, whose zero lay in the lower surface of the float, and whereof the six uppermost inches, from 28 to 34, were divided into 20ths.

That the whole column of quicksilver might alternately be covered with the freezing mixture and water of different temperatures, and yet permit its surface to be seen, two eyes of plate glass were screwed into sockets, foldered for that purpose opposite to each other, near the
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top of the vessel, which, in the first set of the third class of experiments, was little more than 29 inches high. The top of the tube passing through the aperture in the lid, one and a half or two inches of the vacuum generally rose above the vessel. That the expansion of the column might be measured as nearly as possible in that part of the tube fronting the center of the eyes, more or less quicksilver, according to the state of the atmosphere, was occasionally put into the cistern, to raise or depress the surface of the column to the proper height. A thin brass ring, whose lower parts were made to spring, embraced with sufficient force the upper part of the tube, permitting it at the same time to be moved freely with the hand. It carried along with it a nonius index, projecting as far as the center of the rod, and consequently applying itself to the divisions of the scale, which was kept in its proper position by passing through a slit fitted for it in an arm attached to the lid. The divisions on the nonius being the same with those of the barometer formerly described, the height of the quicksilver could always be read off to $\frac{1}{500}$ th part of an inch.

The quicksilver having been carefully boiled, as on former occasions, in the tube; and that being filled completely, and held with its open end upwards; the tin vessel was inverted over it, and lowered gradually, till the

ground end could be inserted into the socket with such a degree of force as to prevent it from being too easily removed. The finger being then applied closely to the open end of the tube, the whole apparatus was turned up, and placed over the cistern into which the quicksilver had previously been put, great care being taken not to remove the finger till the lower extremity of the tube was fairly immersed into the quicksilver; when that in the tube was permitted to descend into an equilibrium with the atmosphere. In the first experiment it was found that the water issued by the eyes, and running down the side of the vessel, fell into the cistern. In order to remedy this inconveniency, a circular piece of tin was foldered round the upper part of it, immediately below the eyes; and a flat spout, projecting from it, served as a gutter to throw off the water from the cistern, and from the lamps made use of to bring that in the vessel to boil. Six lamps, each with a double light, were suspended around the trunk of the vessel, to heat the water as equally as possible; though any irregularity of this kind was sufficiently guarded against, by constantly mixing it during the operation. Another lamp of the same kind stood under the cistern, whereby the quicksilver there was kept at the temperature of the water in the vessel, each having its proper thermometer: this last lamp was placed
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and displaced frequently, during the course of every experiment; for the heat was very expeditiously communicated to the iron cistern, and thence to the quicksilver it contained; and both were found to cool very fast, after the lamp was removed. Such was the state of the apparatus, when the first set of this third class of experiments was made. In those of the second set, its height was farther augmented by tin foldered to the top, that a tube of the ordinary length might be wholly immersed in boiling water. The third and last alteration consisted in the occasional application of a detached tin case, equal in diameter to the upper part of the vessel, having a hole in its bottom to admit the top of a long tube to pass. This case was so contrived, that its bottom stood two inches and a half higher than the lid of the vessel, thereby allowing room for the hand to move the index up or down. In this state the apparatus is represented in the view; and its various uses will be best understood from the account of the experiments, which were subdivided into four sets.

Those of the first set were made with tubes of a large bore, upwards of three-tenths of an inch in diameter, of the ordinary length, with a vacuum over the quicksilver of two inches and a half or three inches, part of which reached above the top of the vessel. The mean of three experi-

experiments gave .5258, for the total dilatation of 30 inches of quicksilver, on 180° between freezing and boiling; that, answering to the first 20° , between 32° and 52° , was .0688; that, for the 20° in the middle of the scale, between 112° and 132° , was .058; and the rate for the last 20° , between 192° and 212° , was only .041. From this first set of the third class of experiments, it appeared evident, that the expansion of 30 inches of quicksilver in the barometer, suffering a heat equal to 180° of FAHRENHEIT, instead of exceeding Mr. DE LUC's, as appeared to be the case from the results of the open tube, really fell short of it: and instead of being arithmetical or uniformly the same, for equal changes of temperature, was actually progressive; the expansion answering to the lower part of the scale, being greater than that corresponding to the middle; which again exceeded that for high temperatures. In these experiments, when the water had acquired a heat 20 or 30 degrees greater than that of the open air, a certain dustiness was perceived in the vacuum of the tube. At 100° of FAHRENHEIT, or thereabout, this appearance had so far increased, as to shew clearly, that it could proceed from no other cause than a vapour arising from the surface of the heated quicksilver, quite invisible, till, by its condensation in the cold part of the tube, it was formed into balls, every where adhering to
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its sides and summit. These globules were very small near the surface of the water, augmenting gradually as they approached the top of the tube, where they were greatest: their bulk increased with the heat; and when the water was at or near boiling, they would sometimes unite, and descend by their own gravity, along the sides of the tube, into the general mass. Hence the progressive diminution of the rate of expansion of the column of quicksilver in the barometer, perceptible even in the first class of experiments, is easily accounted for by the resistance of the elastic vapour^(c), acting against the top of the tube, which was here colder than the rest.

But in the application of the barometer to the measurement of heights, the whole instrument is of the same temperature; wherefore, in the second set of this third class of experiments, the tin vessel was heightened, that tubes of the ordinary length, placed in it, might be wholly immersed in boiling water. The mean of four experiments, which agreed very nearly among themselves, gave .5117 for the total expansion between freezing and boiling; for the 20°, between 112° and 132°.059; and for the last 20°, between 192° and 212°.046. In these

(c) Having mentioned the circumstances to Mr. RAMSDEN, it first occurred to him, that the resistance of the elastic vapour was the cause of the diminution in the rate of expansion.

experiments; the tube being wholly covered with boiling water, no condensation of vapour took place in the vacuum; and therefore no particles of quicksilver were seen adhering to the upper part of the tube. When the water boiled, the resistance of the vapour was greater than in the preceding set, and the total expansion less. These two results serve strongly to confirm each other: it is, however, the last that furnishes the data for constructing the table of equation depending upon the heat of the quicksilver in the barometer, of which table we shall give an account hereafter.

Finding, from the comparison of these two sets of experiments with each other, that the maximum and rate of expansion seemed to vary with the length of the vacuum above the quicksilver, I was advised to try^(d) what might be the result, when the vacuum was much longer than in the common barometer.

The third set of experiments of this class was therefore made with a tube somewhat narrower in the bore than the former, and whose vacuum was $14\frac{1}{2}$ inches in length, whereof $11\frac{1}{2}$ reached above the top of the vessel. The mean of three observations gave .5443 for the total expansion on 180° ; that for the first 20° was .067; for

(d) Dr. BLADEN, who afterwards assisted in some of the first experiments with the manometer, proposed that with the long tube.

the 20° in the middle of the scale .058; and for the uppermost 20° .065: whence the mean rate for every 20° , is nearly .0605^(e). In this set, the condensation in the vacuum of the tube was particularly attended to: it began, as in those of the first set, immediately above the surface of the boiling water, which was always kept an inch or two above the top of the column: the lowermost globules were very small, increasing gradually till they got without the lid of the vessel, where they were the largest; thence they diminished uniformly upwards, and disappeared entirely three or four inches below the top of the tube. Though the rate for the middlemost 20° , in these last experiments, be below the mean, probably from some inaccuracy in observation; yet, being compared with the former sets, they still serve to corroborate each other: for in these with the long tube, the vacuum seems to have been either completely maintained, or nearly so; and we accordingly find the maximum of expansion increased, and its rate rendered nearly uniform, as will be farther confirmed from what follows.

(e) Mr. CAVENDISH, who assisted in the first part of the experiments with the open tube, informed me, that, in those made by his father Lord CHARLES, the difference between the expansion of quicksilver and glass, from 180° of heat, was .469. If to this we add Mr. SMEATON's dilatation of glass, the total expansion of 30 inches of quicksilver will be .544, which agrees with the experiments in the long tube, and gives a rate of only .003022 for each degree.

I have already had occasion to mention that a detached tin case was sometimes applied above the vessel, in which state it is represented in the view. This method was thought of during the operations with the long tube, in order to try whether the vacuum was completely maintained by the temperature of the open air? For this purpose the case was placed on the stones of the yard, with a small tube inserted in it, to preserve an open passage in the middle: it was then rammed full of a composition of salt and ice; and afterwards fixed on the top of the long tube. The degree of cold thus applied round the greatest part of the vacuum, must have been very great, probably near the zero of FAHRENHEIT; yet it produced no visible alteration in the height of the column of quicksilver, which still remained in boiling water below, and should have risen, if the vacuum had been formerly incomplete. As it would have occasioned much trouble to have lengthened the several parts of the apparatus so as to have kept the long tube wholly in boiling water, the counterpart of this last experiment was not made in the accurate manner it ought: nevertheless, the tin case, being emptied of its cold composition, was placed on the tube as before, and filled with boiling water; which, joining with the intermediate steam arising from that in the vessel below, must have kept the whole nearly in the same

same temperature. The consequence of this application was, that the column shortened about $\frac{2}{100}$ ths of an inch; which seems to prove, that the quicksilver vapour now reached the summit of the tube, and, acting against it, overcame, by so much, the pressure of the atmosphere.

I should now proceed to give some account of the fourth set of this last class of experiments, made on the condensation of the quicksilver, by means of artificial cold; below the temperature of the air. Previously however to this, it may not be improper to take notice, in a more general way, of some others that were made on expansion; as tending, with certain circumstances yet to be mentioned, not only to confirm those already described, but likewise to account for many irregularities that occur in operating with barometers.

In the course of the preceding experiments, from accidents of various kinds, it was often necessary to reboil the quicksilver; and in that operation, many tubes were broken. The frequent removal of the socket from the bottom of the vessel, in order to get others ground for it, became at last very troublesome; and made more caution necessary, in boiling such as were ground, especially in frosty weather, which happened to be the case in the last days of March, 1775: wherefore it was thought best in the interim to try, what might be the expansion of a column

of quicksilver, carefully put into the tube, but not boiled therein?

With this view, the standard barometer and apparatus were left out during the night of the 29th, that they might acquire the same temperature, which was found next morning to be $34^{\circ}\frac{1}{2}$; the unboiled quicksilver standing $\frac{1}{100}$ th of an inch higher than that which had been boiled. The lamps being applied to the vessel, the lengthening of the unboiled column was perceived, on the whole, to be more irregular, and the progressive diminution quicker, than in former experiments; so as to give, for the maximum of expansion, only .443 for 180° .

On the morning of the 31st, the unboiled column, which on the preceding day had been the highest, was lower than the other by near $\frac{2}{100}$ ths of an inch, the temperature of both being $31^{\circ}\frac{1}{2}$. As the water acquired heat from the application of the lamps, the rate of expansion diminished; and, at boiling, was only .405 for 180° . The operation of the 30th seems to point out, in a manner sufficiently conclusive, that the air contained in the unboiled quicksilver, rendered its specific gravity less, than that which had been boiled even a great while before; since it required a longer column of the first, to counterbalance the weight of the atmosphere. And though the vacua might possibly, at the beginning, have been equally compleat

complete in both; yet they could not continue long so: for the air escaping gradually from the unboiled quicksilver, its elasticity increasing with the heat, and uniting with the quicksilver vapour, must have resisted the dilatation of the column, and rendered it less than on former occasions; which actually appeared from experiment. This is farther confirmed by the observations of the subsequent day; for now the unboiled column was become the shortest, owing no doubt to more air having ascended, and rendered the vacuum still more incomplete. Thus, the causes of resistance increasing, the dilatation is lessened in a superior degree.

The other circumstances to be mentioned, occurred on the 12th of April. After finishing one of the experiments of the second class, and when the water had cooled to 192° , the vessel, by accident, received a sudden jolt, whereby the mouth of the tube must have been raised, for a moment, out of the quicksilver in the cistern. In a few minutes after this, intending to observe how far the column had shortened from the decreasing heat, I was surprized to find, that the quicksilver had wholly disappeared in the tube, and was sunk so low as not to be seen by looking obliquely down at the eye of the vessel. It was then certain that air, and probably a particle of moisture along with it, had ascended into the upper part of the tube, whereby

whereby the vacuum was destroyed in so remarkable a degree. Since this accident made it necessary to reboil the quicksilver, the water (then between 180° and 190°) was let out by the cock fixed for that purpose at the bottom of the vessel; but before it could be intirely drawn off, the tube and its contents, had so sensibly felt the condensing force of the surrounding atmosphere, then about 48° , that the quicksilver had risen again, and presented itself opposite to the eye of the vessel, something lower indeed than where it formerly stood. On this discovery, and as soon as water could be boiled for the purpose, the vessel was filled again, when the quicksilver subsided, as before, quite out of sight; and on drawing off the water a second time, it rose anew, seemingly to its former height.

The appearance, which this accidental circumstance produced, was such, as naturally suggested that farther experiments might have been made, varied as much as possible from each other, by the admission of different quantities of air, or of air and moisture intermixed. But the nature of the vessel rendering it impossible to see, and consequently to measure, the motion of the quicksilver, occasioned by the alternate expansion and condensation of the elastic vapour contained in the upper part of the tube, and which could not have been accomplished

plished without many troublesome alterations in the apparatus, therefore nothing of the kind was attempted. From the circumstances just now mentioned, it will be readily conceived, how much care is necessary in operating with barometers for the measurement of heights, that the vacua be as nearly as possible compleat; and particularly, that no moisture get up into the tube. I now proceed to the fourth and last set of experiments.

Having found, from the two first sets of this class, the rate of expansion of a column of quicksilver, in the tube of a barometer of the ordinary length, to be progressive and not arithmetical; and that its maximum, for the 180° comprehended between freezing and boiling, was less than had been supposed; I thought it proper to try, by means of artificial cold, whether the condensation, for the 32° below freezing, followed nearly the same law?

For this purpose the tin vessel, containing the ground tube, was rammed quite full of pounded ice and salt, as well as the tin stand holding the iron cistern below. In this operation, twelve pounds of ice and four pounds of salt were employed, whereby the mean temperature of the mixture was reduced to $+4^{\circ}$ of FAHRENHEIT. But before the eyes of the vessel could be sufficiently freed from the composition, so as to permit the surface of the column to be distinctly seen and read off; it had risen to

+ 14° ; the temperature of the air, and also of the standard barometer, being at the same moment $49^{\circ}\frac{1}{2}$. The observed condensation, arising from this difference of $35^{\circ}\frac{1}{2}$, was $\frac{1.2}{100}$ ths of an inch; or .1189, when reduced for the height of the barometer, which then stood at 30.296. Hence the condensation for 32° is .1072, or .00335 for each degree. In this day's experiment, when the temperature of the mixture had risen to 32° , that of the air and standard barometer was $52^{\circ}\frac{1}{4}$; whence the reduced difference, for the 20° between 32° and 52° , was found to be .0664, answerable to former experiments.

The same experiment was repeated two days after, with great care, the vessel being filled no higher than the surface of the quicksilver. The mean temperature of the mixture was now $+4^{\circ}$, and that of the standard barometer $49^{\circ}\frac{1}{4}$. The observed condensation, arising from this difference of $45^{\circ}\frac{1}{4}$, was $\frac{1.62}{1000}$; or .1594, when reduced for the height of the barometer, then standing at 30.416: hence the rate for 32° is .1127, or .003522 for each degree. When the temperature of the mixture had risen to 32° , that of the air was 51° : whence the augmented rate for the 20° , between 32° and 52° , was found to be .0662.

From the mean of these two experiments it appears, that the condensation of a column of 30 inches of quicksilver



quickfilver in the barometer, affected by the 32° of cold below freezing, is .1099: and that the expansion from 20° of heat, between 32° and 52° , is .0663, a number agreeing perfectly well with former results. If the condensation .1099 thus found, be added to the expansion .5117 arising from the second class of experiments, we shall have .6216 for the total difference of height of the columns of quickfilver in two barometers, sustaining the same pressure, but differing from each other in their temperatures 212° of FAHRENHEIT'S thermometer.

The series of numbers expressed in the annexed table, agreeing in all essential respects with the expansions found by experiment, will therefore shew that which corresponds to any intermediate temperature, for every 10° of the scale.

Rate of expansion of a column of quicksilver in the tube
of a barometer.

	Temperature.	Expansions.	Differences.	2d Differences.
Expansion above 32° of FAHRENHEIT; equation to be subtracted from the height of the column of quicksilver of 30 inches.	212	.5117		
	202	.4888	.0229	
	192	.4652	.0236	
	182	.4409	.0243	
	172	.4159	.0250	
	162	.3902	.0257	
	152	.3638	.0264	
	142	.3367	.0271	
	132	.3090	.0277	
	122	.2807	.0283	
	112	.2518	.0289	
	102	.2223	.0295	
	92	.1922	.0301	
	82	.1615	.0307	
	72	.1302	.0313	
	62	.0984	.0318	
	52	.0661	.0323	
	42	.0333	.0328	
	32	.0000	.0333	
	22	.0338	.0338	
Condensation below 32° of FAHRENHEIT; equation to be added.	12	.0681	.0343	
	2	.1029	.0348	
	0	.1099	.0070	

.0007

.0006

.0005

Construction and application of the table of equation, for the expansion of the quicksilver in the tubes of barometers.

In the introduction to this paper there was occasion to remark, that in the application of the barometer to the measurement of heights, various modes of calculation had been adopted. The easiest and best method seems however to be, by means of the tables of common logarithms, which were first thought of by Mr. MARIOTTE, and afterwards applied by Dr. HALLEY, Mr. BOUGUER, Mr. DE LUC, and others. They have all proceeded on the supposition, that air is a truly homogeneous and elastic fluid, whose condensations being proportionable to the weights with which it is loaded, its dilatations are in the inverse of the weights; and in consequence of this law, that the heights of the atmosphere ascended, are in geometrical progression, while the corresponding successive descents of the quicksilver in the tube of the barometer, are in arithmetical progression.

Mr. DE LUC makes use of an arithmetical or uniform equation for the heat of the quicksilver in his barometers, whereby their relative heights are reduced to what they would have been in the fixed temperature of $54^{\circ}\frac{1}{4}$

of FAHRENHEIT. In the formulæ adapting his rule to English measures (Phil. Trans. vol. LXVII. N° xx. and xxx.) hath been shewn, that the easiest and simplest method is, to make the difference of temperature of the two barometers the argument for the equation; and that it is sufficient to reduce either column to what would have been its height in the temperature of the other. But whatever may heretofore have been the method of using the equation for the heat of the quicksilver, while it was considered as arithmetical; now that it hath been shewn, from the preceding experiments, to be progressive, there seems at least to be propriety in applying to each barometer the equation answering to its particular temperature. And though, for this purpose, any fixed temperature might have been assumed at pleasure, as that to which both barometers were to be reduced; yet, the freezing point being fundamental in all thermometers, and that being likewise the zero of the scale for the equation depending on the heat of the air, as will be shewn hereafter, it hath been preferred to any other.

From the experiments it appears, that a column of quicksilver of the temperature of 32° , sustained, by the weight of the atmosphere, to the height of 30 inches in the barometer, when gradually affected by different degrees of heat, suffers a progressive expansion; and that,

having

having acquired the heat of boiling water, it is lengthened $\frac{5117}{10000}$ parts of an inch : also, that the same column, suffering a condensation by 32° of cold, extending to the zero of FAHRENHEIT, is shortened $\frac{1099}{10000}$ parts, the weight of the atmosphere remaining in both cases unaltered ; but that, in the application of the barometer to the measurement of altitudes, since the pressure and length of the column change with every alteration of vertical height, the equation, depending on the difference of temperature of the quicksilver, will necessarily augment or diminish by a proportionable part of the whole. Thus, if the weight of the atmosphere should at any time be so great as to sustain 31 inches of quicksilver, the equation for difference of temperature will be just $\frac{1}{30}$ th part more than that for 30 inches ; at 25 inches it will be $\frac{1}{6}$ ths ; at 20 inches $\frac{1}{3}$ ds ; at 15 inches $\frac{1}{2}$; and at 10 inches only $\frac{1}{3}$ d of that deduced from experiment.

It is upon these principles that the annexed table of equation hath been constructed, for differences of temperature extending to 102° of the thermometer, and for heights of the barometer from 15 to 31 inches ; beyond which limits, it is not probable, that many barometrical observations will be made. The first or left-hand column, shews the height of the barometer for every half inch, from 31 to 25 ; thence for every inch downwards

to 20; the 15th inch being half of the observed expansion. The five next columns towards the right, comprehend the additive equation for condensations, answering to 0°, 12°, and 22°, with their intermediate differences; those that are progressive, as arising from difference of temperature, being ranged horizontally; and those that are arithmetical, as depending on the height of the barometer, being placed vertically. The temperature of 32° requires no equation, and the thirteen columns from thence towards the right hand, contain the subtractive equations for expansion, corresponding to every 10° as far as 102°, with their progressive and arithmetical differences ranged as before. By means of these differences, the equation for intermediate temperatures may readily be taken out by inspection. Hence is deduced the first part of the rule for measuring heights by the barometer. When the temperature of the quicksilver is below 32° of FAHRENHEIT, add the corresponding equation for condensation to the observed heights of the columns respectively; when above 32°, subtract the equation for expansion from the observed heights of the columns respectively; with which equated heights of quicksilver, expressed in 1000th parts of an inch, the tables of logarithms are to be entered.

Table

Table, shewing the equation to be applied to the observed height of quicksilver in the barometer, for the temperature extending to 102° of FAHRENHEIT: whereby the column is reduced to the height it would be at 32°.

Observed height of quicksilver in the Barom.	Condensation below 32°; Equation to be added to the height of the quicksilver in the barometer.						32°	Expansion above 32°				
	0°	Diff.	12°	Diff.	22°			42°	Diff.	52°	Diff.	
31	.1136	.0432	.0704	.0355	.0349	When the temperature of the quicksilver in the barometer is 32° of FAHRENHEIT, no equation is necessary.		.0344	.0339	.0683	.0339	
30½	.1118	.0425	.0693	.0349	.0344			.0339	.0333	.0672	.0333	
30	.1099	.0418	.0681	.0343	.0338			.0333	.0328	.0661	.0328	
29½	.1081	.0411	.0670	.0338	.0332			.0327	.0323	.0650	.0323	
29	.1063	.0405	.0658	.0331	.0327			.0322	.0317	.0639	.0317	
28½	.1045	.0398	.0647	.0326	.0321			.0316	.0312	.0628	.0312	
28	.1026	.0390	.0636	.0321	.0315			.0311	.0306	.0617	.0306	
27½	.1008	.0384	.0624	.0314	.0310			.0305	.0301	.0606	.0301	
27	.0990	.0377	.0613	.0309	.0304			.0300	.0295	.0595	.0295	
26½	.0971	.0370	.0601	.0302	.0299			.0294	.0290	.0584	.0290	
26	.0953	.0363	.0590	.0297	.0293			.0289	.0284	.0573	.0284	
25½	.0935	.0356	.0579	.0292	.0287			.0283	.0279	.0562	.0279	
25	.0916	.0349	.0567	.0285	.0282			.0278	.0273	.0551	.0273	
24	.0880	.0336	.0544	.0273	.0271			.0266	.0263	.0529	.0263	
23	.0843	.0321	.0522	.0263	.0259			.0255	.0252	.0507	.0252	
22	.0807	.0408	.0399	.0251	.0248			.0244	.0241	.0485	.0241	
21	.0770	.0294	.0476	.0239	.0237			.0233	.0230	.0463	.0230	
20	.0733	.0280	.0453	.0228	.0225			.0221	.0220	.0441	.0220	
15	.0550	.0211	.0339	.0170	.0169			.0166	.0165	.0331	.0165	

quickfilver in the barometer, from 15 to 31 inches; and for differences of
 an is reduced to the height it would have stood at in the temperature of 32°.

above 32°; Equation to be subtracted from the height of the quickfilver in the Barometer.

	Diff.	62°		Diff.	72°		Diff.	82°		Diff.	92°		Diff.	102°	
.01102 }.001102	.0334	.1017	}.00164	.0328	.1345	}.00217	.0324	.1669	}.002692	.0317	.1986	}.003203	.0311	.2297	}.003705
	.0328	.1000		.0323	.1323		.0319	.1642		.0312	.1954		.0306	.2260	
	.0323	.0984		.0318	.1302		.0314	.1616		.0306	.1922		.0301	.2223	
	.0318	.0968		.0312	.1280		.0309	.1589		.0301	.1890		.0296	.2186	
	.0312	.0951		.0307	.1258		.0304	.1562		.0296	.1858		.0291	.2149	
	.0307	.0935		.0302	.1237		.0298	.1535		.0291	.1826		.0286	.2112	
	.0301	.0918		.0297	.1215		.0293	.1508		.0286	.1794		.0281	.2075	
	.0296	.0902		.0291	.1193		.0288	.1481		.0281	.1762		.0276	.2038	
	.0291	.0886		.0285	.1171		.0283	.1454		.0276	.1730		.0271	.2001	
	.0285	.0869		.0281	.1150		.0277	.1427		.0271	.1698		.0266	.1964	
.01102 }.002204	.0280	.0853	}.00328	.0275	.1128	}.00434	.0272	.1400	}.005384	.0266	.1666	}.006406	.0261	.1927	}.007410
	.0275	.0837		.0269	.1106		.0267	.1373		.0261	.1634		.0256	.1890	
	.0269	.0820		.0265	.1085		.0261	.1346		.0256	.1602		.0251	.1853	
	.0258	.0787		.0254	.1041		.0252	.1293		.0245	.1538		.0240	.1778	
	.0248	.0755		.0243	.0998		.0241	.1239		.0235	.1474		.0230	.1704	
	.0237	.0722		.0232	.0954		.0231	.1185		.0225	.1410		.0220	.1630	
	.0226	.0689		.0222	.0911		.0220	.1131		.0215	.1346		.0210	.1556	
	.0215	.0656		.0211	.0867		.0210	.1077		.0204	.1281		.0201	.1482	
	.0161	.0492		.0158	.0650		.0158	.0808		.0153	.0961		.0150	.1111	

S E C T I O N II.

Experiments on the expansion of air in the Manometer.

WITH respect to order of time, the manometrical experiments were made subsequently to the chief part of the barometrical observations, from which alone an approximate rule had previously been deduced for the measurement of heights: nevertheless, in this paper it seemed to me best, that what related to the expansion of air in one instrument, should immediately succeed the expansion of quicksilver in the other.

The thermometer made use of in these experiments is above four feet long. Its scale extends from -4° to $+224^{\circ}$ of FAHRENHEIT, each degree being more than $\frac{2}{10}$ ths of an inch: when the barometer stood at 30 inches, its boiling point was fixed in the tin vessel formerly described. Mr. RAMSDEN's thermometers generally rise in the same vessel $213\frac{1}{2}$; and the long thermometer, being placed in the vessel he makes use of to fix his boiling points, rises only to 210° .

The manometers were of various lengths, from four to upwards of eight feet: they consisted of straight tubes,

whose bores were commonly from $\frac{1}{15}$ th to $\frac{1}{25}$ th of an inch in diameter. The capacity of the tube was carefully measured, by making a column of quicksilver, about three or four inches in length, move along it from one end to the other. These spaces were severally marked, with a fine edged file, on the tubes; and transferred from them to long slips of paste-board, for the subsequent construction of the scales respectively belonging to each. The bulb, attached to one end of the manometer at the glass house, was of the form of a pear, whose point being occasionally opened, dry or moist air could be readily admitted, and the bulb sealed again, without any sensible alteration in its capacity.

The air was confined by means of a column of quicksilver, long or short, and with the bulb downwards or upwards, according to the nature of the proposed experiment. Here it must be observed that, from the adhesion of the quicksilver to the tube, the instrument will not act truly, except it be in a vertical position; and even then, it is necessary to give it a small degree of motion, to bring the quicksilver into its true place; where it will remain in equilibrio, between the exterior pressure of the atmosphere on one side, and the interior elastic force of the confined air on the other.

All

All the experiments were made when the barometer was at, or near, 30 inches. When the bulb was downwards, the height of the barometer at the time of observation, augmented, and when upwards, diminished by the number of inches of quicksilver in the tube of the manometer, expressed the density of the confined air.

Pounded ice and water were used to fix a freezing point on the tube; and by means of salt and ice, the air was farther condensed, generally four, and sometimes five or six degrees below zero. The thermometer and manometer were then placed in the tin vessel, among water which was brought into violent ebullition; where having remained a sufficient time, and motion being given to the manometer, a boiling point was marked thereon. After this the fire was removed, and the gradual descents of the piece of quicksilver, corresponding to every 20 degrees of change of temperature in the thermometer, were successively marked on a deal rod applied to the manometer. It is to be observed, that both instruments, while in the water, were in circumstances perfectly similar; that is to say, the ball and bulb were at the bottom of the vessel.

In order to be certain that no air had escaped by the side of the quicksilver during the operation, the manometer was frequently placed a second time in melting

ice. If the barometer had not altered between the beginning and end of the experiment, the quicksilver always became stationary at or near the first mark. If any sudden change had taken place in the weight of the atmosphere during that interval, the same was noted, and allowance made for it in afterwards proportioning the spaces.

Long tubes, with bores truly cylindrical or of any uniform figure, are scarcely ever met with. Such however as were used in these experiments, generally tapered in a pretty regular manner from one end to the other. When the bulb was downwards, and the tube narrowed that way, the column of quicksilver confining the air lengthened in the lower half of the scale, and augmented the pressure above the mean. In the upper half, the column being shortened, the pressure was diminished below the mean. In this case, the observed spaces both ways from the center, were diminished in the inverse ratio of the heights of the barometer at each space, compared with its mean height. If the bore widened towards the bulb when downwards, the observed spaces, each way from the center, were augmented in the same inverse ratio; but in the experiments on air less dense than the atmosphere, the bulb being upwards, the same equation was applied with contrary signs: and if any

extraordinary irregularity took place in the tube, the corresponding spaces were proportioned both ways from that point, whether high or low, that answered to the mean.

The observed and equated manometrical spaces being thus laid down on the paste-board containing the measures of the tube; the 212° of the thermometer, in exact proportion to the sections of the bore, were constructed along-side of them: hence the coincidences with each other were easily seen; and the number of thermometrical degrees answering to each manometrical space, readily transferred into a table prepared for the purpose.

I have already had occasion to remark that, from the operations of the barometer alone, an approximate rule, or mean equation, had been obtained for the measurement of heights; but as, among the results, irregularities were now and then met with, doubts naturally arose, whether the equation, instead of being considered as uniform, might not follow an increasing or diminishing progression? Without an infinite number of observations, in very different temperatures above and below the zero of the scale, this point could not possibly be determined by the barometer: wherefore the first and chief thing proposed to be discovered by the manometrical experiments was, whether common air, occasionally rendered

more or less dense, by the addition or subtraction of weight, expanded equally with quicksilver, when affected with the same degrees of heat? According to the ratio that took place between the expansion of quicksilver and air, above and below zero, I intended to regulate the barometrical equation already found, without regarding the proportion of the bulb to the bore of the manometer; or in other words, without paying any attention to the actual expansion of the air confined in that instrument.

But after a great number of these first experiments had been made, it was judged proper to compute the actual expansion of 1000 equal parts of air in the manometer, from a heat of 212° ; wherefore, in the last, the accurate capacity of the bulb, with respect to the bore, was determined; at the same time that the original mode of comparing the thermometrical with the manometrical spaces, was still adhered to.

It is easy to conceive in experiments of this very delicate nature, part of which, namely those on air less dense than the atmosphere, were extremely difficult and even laborious, that mathematical exactness was not to be looked for; and that, notwithstanding every possible precaution was taken, irregularities would occur. These, however, were not so numerous as might have been
I expected,

expected, nor any way so great as to render the research fruitless: for a few of that kind being thrown out of the total number, the mean of the others, which were very consistent among themselves, served to prove beyond the possibility of doubt, that the expansions of common air did not keep pace with the dilatations of quicksilver. The manometrical space, answering to the 20° of the thermometer between 52° and 72° , was always found to be greater than any other 20° of the scale. Here it is to be understood, that I do not pretend to have ascertained the exact point in that space where the maximum falls: the mean corresponds to the 62d degree, and yet I am inclined to think that it is somewhat lower, perhaps it may be about the 57th: from this point, the condensations of air downwards, and its expansions upwards, follow a diminishing progression, compared with the condensations and dilatations of quicksilver. The manometrical are equal to the thermometrical spaces, in two points of the scale; namely, at or near the freezing temperature on one side, and between the 112° and 132° degrees of the scale on the other. At the zero and boiling point they are less than the thermometrical spaces. Whether this maximum of expansion of air, compared with that of quicksilver, be owing to moisture, or any thing.

thing else mixed with the former, which is brought into its greatest degree of action, about the temperature of 57° of FAHRENHEIT, must be left to the investigations of future experimenters: I only relate things as I found them after many repetitions, without being able to discover any material difference in the results, even when the air was rendered more or less dense by an addition to, or subtraction from, the weight wherewith it was loaded. The thermometrical, compared with the manometrical spaces, will therefore appear as in the following table.

Spaces of the quicksilver
thermometer, FAHREN-
HEIT's scale.

Spaces of the manometer,
measured in degrees of
FAHRENHEIT.

212	212
20	17.6
192	194.4
20	18.2
172	176.2
20	18.8
152	157.4
20	19.4
132	138.0
20	20.0
112	118.0
20	20.8
92	97.2
20	21.6
72	75.6
20	22.6
52	53.0
20	21.6
32	31.4
20	20.0
12	11.4
0	0

Experiments, for determining the actual expansion of common air, in the manometer, affected by the heat of 212°.

For this purpose it became necessary to ascertain, in every manometer, the exact proportion between the capacity of the tube and that of its bulb. This was done, by weighing the quicksilver that filled them respectively, in a balance that was sensible to a very small fraction of a grain. The contents of the bulb, and that part of the tube between it and zero, expressed in grains, was called the air in experiment. The apparent expansion of that air was measured, by the grains that filled the several sections of the tube between zero and the boiling point; the sum being the total expansion or increase of volume, from a heat of 212°. The apparent expansion, thus found, was again augmented for the dilatation of the tube, on the following principles.

In the first part of this paper I have shewn, that solid glass rods dilate much less than barometer tubes. The mean between Mr. SMEATON'S and my experiments, gives $\frac{14}{1000}$ of an inch for the longitudinal extension of every foot of these tubes, by 212°. From the rate of going of a clock, for near a year, whose pendulum rod is solid glass, its dilatation seems to be one-third part of a steel rod,

or

or $\frac{58}{10000}$ on a foot, by 212° . Now, as the manometers resemble solid rods much more than they do barometer tubes, it is probable their dilatation, even allowing for the greater extension of the bulb, would not exceed $\frac{6}{1000}$ ths of an inch on a foot, or $\frac{1}{1000}$ th part on every two inches. In this ratio I have therefore augmented the apparent, to obtain the true, capacity of each manometer. The equation, amounting to about $\frac{1}{120}$ th part of the whole, being less than the common error of such complicated observations, might in fact have been entirely omitted, without producing any material alteration in the results.

Having, in this manner, computed the total increased volume of any number of equal parts of air (according to the capacity of the bulb and tube in grains) and very often likewise the partial expansions for intermediate temperatures, expressed by the contents of the corresponding sections of the tube, I then found the ratio answering to 1000 equal parts, which, being divided by the degrees of difference of temperature, gave the mean rate for the whole scale, or the particular rate for any intermediate section of it.

The experiments, considered in this way, are distributed into four classes, whereof the results are comprehended in the four following tables. The first shews the expansion of air, whose density was much greater than that of the

common atmosphere. The second, which is divided into two sets, contains those on air that sustained a pressure less than the atmosphere. In the third class, a very short column of quicksilver being employed to confine the air, its density differed little from that we commonly breathe in: this class is likewise subdivided into two sets, and it will hereafter be made use of to regulate the equation depending on the temperature of the air, in the application of the barometer. The fourth and last class of experiments, were made on air of the common density, artificially moistened by the admission, sometimes of steam, and at others of water, into the bulb; it is accordingly distinguished into two sets.

TABLE I. Results of experiments on the expansion of air, whose mean density was equal to $2\frac{1}{2}$ atmospheres.

N ^o	Height of the barometer.	Inches of quicksilver confining the air.	Density in inches.	Total expansion of 1000 equal parts of air by 212° .	Mean rate for each degree.
1	29.7	+ 72.	101.7	451.54	2.12991
2	29.7	+ 62.6	92.3	423.23	1.99637
3	29.62	+ 50.84	80.46	412.09	1.94382
4	29.66	+ 24.88	54.54	439.87	2.07486
5	29.66	+ 20.05	49.71	443.24	2.09075
Mean,			75.74	434.00	2.04717

TABLE II. Results of experiments on the expansion of air of the density of first common atmosphere; and of others on air that was extremely rare, being only about one-fifth of an atmosphere.

First set.

N ^o	Height of the barom.	Inches of quick-silver.	Density in inches.	Total expansion of 1000 equal parts of air by 212°.	Mean rate for each degree.	Expansion for intermediate temperatures					
						From 0 to 32°.	32° to 52°.	52° to 72°.	72° to 92°.	92° to 132°.	
1	29.85	—5.44	24.41	495.455	2.33705	—	—	Not observed.			—
2	29.76	—3.05	26.71	504.340	2.37896	2.27190	2.41666	2.64060	2.55200	2.4604	
3	29.79	—0.53	29.26	470.32	2.21849	1.90437	2.48150	2.63150	2.59650	2.1509	
4	30.09	—5.43	24.66	469.07	2.21259	2.32688	2.53450	2.66250	2.24800	2.2542	
5	29.93	—9.63	20.30	479.20	2.26038	2.14750	2.49500	2.59850	2.24700	2.2595	
Mean,			25.17	483.677	2.28140	2.16266	2.48191	2.63327	2.41087	2.281	

Difference of temperature.

Second set.

6	Experiment in a heated room in Philpot lane, February 25, barometer 30.03 — 4.82 = 25.21 the density of the air,	on 113½ from 48½ to 162
		51½ 48½ 100
		62 100 162
7	In Philpot lane; tube with a small bore; barometer 30.03 — 23.2 = 6.77 the density. The air had been heated red-hot in the bulb before it was sealed,	on 113½ from 48½ to 162
		51 48½ 101½
		60½ 101½ 162
	The expansion for 212°, at the mean rate, would be	— — — —
8	In Pulteney street, February 28th; with the same manometer that had been used in the same experiment in Philpot lane, barometer 30.08 — 23.2 = 6.88 the density of the air,	on 212 — —
		32 above zero.
		20 from 32 to 52
		80 52 132
		60 132 192
		20 192 212
9	In Pulteney street, April 19th; tube with a large bore, barometer 29.8 — 24.08 = 5.72 the density of the air, which had been heated red-hot in the bulb before it was sealed,	on 180 from 32 to 212
		20 32 52
		20 52 72
		20 72 92
		20 92 112
		20 112 132
		20 132 152
		20 152 172

s of experiments on the expansion of air of the density of five-sixths of the
sphere; and of others on air that was extremely rare, being only pressed with
a of an atmosphere.

	Density in inches.	Total expan- sion of 1000 equal parts of air by 212°.	Mean rate for each degree.	Expansion for intermediate temperatures.							
				From 0 to 32°.	32° to 52°.	52° to 72°.	72° to 92°.	92° to 132°.	132° to 172°.	172° to 212°.	
44	24.41	495.455	2.33705	—	—	Not observed.			—	—	—
05	26.71	504.340	2.37896	2.27190	2.41666	2.64060	2.55200	2.46040	2.31850	2.20748	
53	29.26	470.32	2.21849	1.90437	2.48150	2.63150	2.59650	2.15050	2.12000	2.10925	
43	24.66	469.07	2.21259	2.32688	2.53450	2.66250	2.24800	2.25425	2.05325	1.83525	
63	20.30	479.20	2.26038	2.14750	2.49500	2.59850	2.24700	2.25950	2.21375	2.11850	
	25.17	483.677	2.28140	2.16266	2.48191	2.63327	2.41087	2.28116	2.17637	2.06762	

Difference of temperature.				Total ex- pansion.	Mean rate.
in a heated room in Philpot lane, February 25, barometer 30.03 — 4.82 = 25.21 the density of the air, —	{	on 113½ from 48½ to 162		244.604	2.15510
		51½ 48½ 100		126.311	2.45264
		62 100 162		118.293	1.90800
Philpot lane; tube with a small bore; barometer 30.03 — 23.2 = 6.88 the density of the air, which had been heated red-hot in the bulb and was sealed, — — —	{	on 113½ from 48½ to 162		138.75	1.22247
		51 48½ 101½		71.93	1.41039
		60½ 101½ 162		66.82	1.10446
Expansion for 212°, at the mean rate, would be — — — —				259.164	
Newington street, February 28th; with the same manometer that was used in the same experiment in Philpot lane, barometer 30.03 — 23.2 = 6.88 the density of the air, — —	{	on 212 — —		330.487	1.55890
		32 above zero.		44.574	1.39294
		20 from 32 to 52		37.771	1.88855
		80 52 132		139.784	1.74730
		60 132 192		94.804	1.58007
		20 192 212		13.554	0.67770
Newington street, April 19th; tube with a large bore, barometer 30.08 = 5.72 the density of the air, which had been heated in the bulb before it was sealed, — —	{	on 180 from 32 to 212		141.504	0.78613
		20 32 52		17.845	0.89225
		20 52 72		25.943	1.29715
		20 72 92		20.911	1.04550
		20 92 112		14.937	0.74685
		20 112 132		14.228	0.71140
		20 132 152		14.151	0.70755
		20 152 172		14.150	0.70750

First set.

N ^o	Height of the barom.	Inches of quick-silver.	Density in inches.	Total expansion of 1000 equal parts of air by 212°.	Mean rate for each degree.	Expansion for intermediate temperatures				
						From 0 to 32°.	32° to 52°.	52° to 72°.	72° to 92°.	92° to 132°.
1	29.85	—5.44	24.41	495.455	2.33705	—	—	Not observed.		
2	29.76	—3.05	26.71	504.340	2.37896	2.27190	2.41666	2.64060	2.55200	2.46040
3	29.79	—0.53	29.26	470.32	2.21849	1.90437	2.48150	2.63150	2.59650	2.15090
4	30.09	—5.43	24.66	469.07	2.21259	2.32688	2.53450	2.66250	2.24800	2.25420
5	29.93	—9.63	20.30	479.20	2.26038	2.14750	2.49500	2.59850	2.24700	2.25990
Mean,			25.17	483.677	2.28140	2.16266	2.48191	2.63327	2.41087	2.28140

Difference of temperature

6	Experiment in a heated room in Philpot lane, February 25, barometer 30.03 — 4.82 = 25.21 the density of the air,	on 113½ from 48½ to 162
	—	51½ 48½ 100
		62 100 162

7	In Philpot lane; tube with a small bore; barometer 30.03 — 23.2 = 6.77 the density. The air had been heated red-hot in the bulb before it was sealed,	on 113½ from 48½ to 162
	— — —	51 48½ 101½
		60½ 101½ 162
	The expansion for 212°, at the mean rate, would be	— — —

Second set.

8	In Pulteney street, February 28th; with the same manometer that had been used in the same experiment in Philpot lane, barometer 30.08 — 23.2 = 6.88 the density of the air,	on 212 — —
	— —	32 above zero.
		20 from 32 to 52
		80 52 132
		60 132 192
		20 192 212

9	In Pulteney street, April 19th; tube with a large bore, barometer 29.8 — 24.08 = 5.72 the density of the air, which had been heated red-hot in the bulb before it was sealed,	on 180 from 32 to 212
	— —	20 32 52
		20 52 72
		20 72 92
		20 92 112
		20 112 132
		20 132 152
		20 152 172
		20 172 192
		20 192 212

The Expansion for 212° at the mean rate would be, — — —

Mean of the three means; density 6.46, expansion for 212°, — — —

Thermometer.	Density in inches.	Total expansion of 1000 equal parts of air by 212°.	Mean rate for each degree.	Expansion for intermediate temperatures.						
				From 0 to 32°.	32° to 52°.	52° to 72°.	72° to 92°.	92° to 132°.	132° to 172°.	172° to 212°.
44	24.41	495.455	2.33705	—	—	Not observed.				
05	26.71	504.340	2.37896	2.27190	2.41666	2.64060	2.55200	2.46040	2.31850	2.20748
53	29.26	470.32	2.21849	1.90437	2.48150	2.63150	2.59650	2.15050	2.12000	2.10925
43	24.66	469.07	2.21259	2.32688	2.53450	2.66250	2.24800	2.25425	2.05325	1.83525
63	20.30	479.20	2.26038	2.14750	2.49500	2.59850	2.24700	2.25950	2.21375	2.11850
	25.17	483.677	2.28140	2.16266	2.48191	2.63327	2.41087	2.28116	2.17637	2.06762

Description of experiment.	Difference of temperature.			Total expansion.	Mean rate.
	on	from	to		
in a heated room in Philpot lane, February 25, barometer 30.03 — 4.82 = 25.21 the density of the air, —	on 113½	from 48½	to 162	244.604	2.15510
	51½	48½	100	126.311	2.45264
	62	100	162	118.293	1.90800
in a heated room in Philpot lane; tube with a small bore; barometer 30.03 — 23.2 = 6.83 the density of the air, —	on 113½	from 48½	to 162	138.75	1.22247
	51	48½	101½	71.93	1.41039
	60½	101½	162	66.82	1.10446
Expansion for 212°, at the mean rate, would be —	—	—	—	259.164	
in a heated room in Philpot lane; tube with a small bore; barometer 30.03 — 23.2 = 6.83 the density of the air, —	on 212	—	—	330.487	1.55890
	32	above zero.	—	44.574	1.39294
	20	from 32	to 52	37.771	1.88855
	80	52	132	139.784	1.74730
	60	132	192	94.804	1.58007
in a heated room in Philpot lane; tube with a small bore; barometer 30.03 — 23.2 = 6.83 the density of the air, —	20	192	212	13.554	0.67770
	on 180	from 32	to 212	141.504	0.78613
	20	32	52	17.845	0.89225
	20	52	72	25.943	1.29715
	20	72	92	20.911	1.04550
in a heated room in Philpot lane; tube with a large bore, barometer 30.08 = 5.72 the density of the air, which had been heated in the bulb before it was sealed, —	20	92	112	14.937	0.74685
	20	112	132	14.228	0.71140
	20	132	152	14.151	0.70755
	20	152	172	14.150	0.70750
	20	172	192	12.264	0.61320
Expansion for 212° at the mean rate would be, —	—	—	—	7.075	0.35375
Expansion for 212° at the mean rate would be, —	—	—	—	166.660	
Expansion for 212° at the mean rate would be, —	—	—	—	252.104	1.18917

TABLE

TABLE III. Results of experiments on the expansion of air of the density of the common atmosphere.

	N ^o	Height of the barom.	Inches of quicksilver confining the air.	Density in inches.	Total expansion of 1000 equal parts of air by 212°.	Mean rate for each degree.
First set; common air.	1	29.95	+ 1.57	31.52	483.89	2.28250
	2	30.07	+ 0.70	30.77	482.10	2.27406
	3	29.48	+ 0.42	29.90	480.74	2.26764
	4	29.90	+ 0.83	30.73	485.86	2.29182
	5	29.96	+ 0.96	30.92	489.45	2.30870
	6	29.90	+ 0.65	30.55	476.04	2.24547
	7	29.95	+ 0.65	30.60	487.55	2.29976
Second set; common air heated red-hot	8	30.07	+ 0.53	30.60	482.80	2.27736
	9	29.48	+ 0.52	30.00	489.47	2.30871
Mean				30.62	484.21	2.28401

The total expansion 484.21 being divided into parts proportionable to the manometrical spaces, measured in degrees of the quicksilver thermometer, as already given; we have the following expansions for intermediate temperatures, the rates for every 10° below 92° being found by interpolation.

Thermo- metrical spaces.	Manome- trical spaces.	Total Expan- sions for degrees above zero, 1000 parts.	Difference of expan- sions, 1000 parts.	Rate for each degree, 1000 parts.
212. ^o	212. ^o	484.210		
192.	194.4	444.011	40.199	2.00995
172.	176.2	402.452	41.559	2.07795
152.	157.4	359.503	42.949	2.14745
132.	138.	315.193	44.310	2.21550
112.	118.	269.513	45.680	2.28400
92.	97.2	222.006	47.507	2.37535
82.	86.6	197.795	24.211	2.42110
72.	75.6	172.671	25.124	2.51240
62.	64.4	147.090	25.581	2.55810
52.	53.	121.053	26.037	2.60370
42.	42.	95.929	25.124	2.51240
32.	31.4	71.718	24.211	2.42110
22.	21.2	48.421	23.297	2.32970
12.	11.4	26.038	22.383	2.23830
0.	—	—	26.038	2.16983

Hence $222.006 - 26.038 = 195.968 = 2.4496$, or 2.45 ,
is the mean rate of expansion for the 80° comprehended
between 12° and 92° of FAHRENHEIT.

y moistened, by the admission of steam, and sometimes water, into the bulb manometer.

Expansion for intermediate temperatures.

2° 52°	52° to 72°	72° to 92°	92° to 112°	112° to 132°	132° to 152°	152° to 172°	172° to 192°	192° to 212°
00	3.02650	3.38050	4.18300	6.48000	8.67750	11.93600	16.85050	—
50	2.90950	3.67650	5.16700	6.93300	10.17500	10.64200	16.57850	8.25400
100	3.04900	3.77550	4.36900	7.60500	8.94400	10.42950	11.92200	11.69000
150	2.74700	3.25500	3.73700	5.91350	9.18950	11.57550	25.88650	—
300	2.96400	3.84750	5.76100	7.19450	12.29850	16.69750	19.29500	25.23550
350	3.11600	3.72300	5.53600	7.83900	12.74100	16.74600	27.84350	45.25000
450	2.90500	3.47750	5.41900	6.16650	7.98850	8.58950	10.93600	4.98600
550	2.80850	3.78700	4.60750	Tube broken.				
650	3.22500	3.76500	5.41700	6.79250	9.14350	9.71100	13.75550	19.93270
800	2.97228	3.63194	4.91072	6.86550	9.89494	12.04087	17.88344	19.22470
867	2.95450	3.64317	4.98500	6.90150	9.03583	9.88700	13.14550	8.31000
833	3.10167	3.77850	5.57133	7.27533	11.39500	14.38483	20.29800	30.13940

1208.72, whence the mean rate is 6.29542.

1367.05, — — 7.12005.

358.03, — — 3.19669.

From

From the experiments of the first class it appears, that 1000 equal parts of common air, loaded with two atmospheres and a half, being affected with a heat of 212° , expands 434 of those parts; that is to say, in its dilated state, it occupies a space bearing, to that which it originally filled, the proportion of 1434 to 1000: hence the mean rate of expansion of air of that extraordinary density is 2.04717 for each degree.

From the first set of the second class of experiments it appears, that 1000 equal parts of air, pressed only with $\frac{2}{5}$ ths of an atmosphere, and suffering a heat of 212° , expands nearly 484 of those parts, whereof the mean rate for each degree is 2.28140. The maximum corresponds to that section of the scale between 52° and 72° ; and the rate for the extremes is less than the mean.

But in the second set of this class, when the confined air was rendered so extremely rare as to be pressed with only one-fifth of an atmosphere, in which case there was a necessity for heating it red-hot before it was possible to make the quicksilver hang in any tube of a moderate length, the expansion of 1000 equal parts of air is, by the seventh and eighth experiments, diminished to about two-thirds of the usual quantity; and by the ninth, it is considerably less, amounting only to 141.5 for the 180°

comprehended between freezing and boiling, or 0.78613 for each degree. The maximum still corresponds to the space between 52° and 72° ; and the minimum is constantly at the boiling point.

From these three last experiments it would seem, that the particles of air may be so far removed from each other, by the diminution of pressure, as to lose a very great part of their elastic force; since, in the ninth experiment, the heat of boiling water applied for an hour together, could only make it occupy a space which, compared with what it filled at freezing, bears the proportion of 1141.5 to 1000.

From the third class of experiments it appears, that common air, pressed with a single atmosphere, whether taken into the manometer in its natural state, or heated red-hot therein, has the same expansion with air of only five-sixths of that density: for 1000 equal parts of this air expanded 484.21 from 212° of heat, whereof the mean rate is 2.28401 for each degree. By comparing this result with that of the first class, and again with that deduced from the second set of the second class, it would seem, that the elastic force of common air is greater than when its density is considerably augmented or diminished by an addition to, or subtraction from, the weight

with which it is loaded^(f); for, in the first case, it bears the proportion of 484 to 434; and in the last, it is (from the

(f) This difference between the elastic force of common air, and that which is artificially rendered more or less dense, by the addition or subtraction of weight, particularly the latter, is truly remarkable, and contradicts the experience of BOYLE, MARRIOTTE, &c. It could not arise from the adhesion of the quicksilver to the tube, though in the dense experiments a column of 72 inches was once made use of; because the constant motion given to the manometer before the spaces were marked, must either have prevented any irregularity whatever, or made the apparent expansion sometimes too great, and at others too little. But the rare experiments serve to put this matter out of doubt; for if the adhesion of the quicksilver to the tube had tended to lessen the apparent expansion of the air, beneath the truth in one case, it must have had a direct contrary effect in the other, and augmented it above the truth, which it evidently doth not.

These experiments on the expansion of air less dense than the atmosphere, were extremely difficult and troublesome; and it was not till after several fruitless attempts that, with the assistance of Dr. LIND, an apparatus was prepared for making them with sufficient accuracy. The vessel employed for this purpose was made of the brass tube of a large telescope, near four inches in diameter; it was divided into four pieces, which, when screwed together, made a pot of six feet in height. This was mounted on a platform laid over the area rails, for the reception of the manometer, which was placed therein, with the bulb uppermost, the lower extremity of the tube passing through a socket at the bottom of the vessel, and then through a collar composed of many thicknesses of flannel. By means of a brass plate and three long screws, the collar was made to embrace the tube so closely, as to suffer very little water to pass: such as did issue, oozed off along the sides of a paper funnel, bound round the end of the tube, without entering into the bore. In this position, it required some degree of force to push the manometer up, or draw it down, till the top of the quicksilver confining the air, just appeared without the collar, so as to admit the spaces to be measured, from a fixed point marked on the tube. The vessel being filled with boiling water, was kept to that temperature by means of lamps sus-
pended

the mean of three experiments) as 484 to 252, when pressed with only one-fifth of an atmosphere.

The

pended around it. Two thermometers were made use of; the long one, whose ball stood at the bottom; and a short one at the top, that descended no lower than just to be immersed in the water. By some of the first of these experiments, the lamps not being placed directly at the bottom, water was perceived to be a very bad conductor of heat; for it would boil violently at the top, and the short thermometer there would mark 212° , while the long one would only mark 185° or 190° at the bottom. By slow degrees the heat would nevertheless descend, and in the space of fifteen or twenty minutes the whole column would become of the same uniform temperature. But when the apparatus was adapted for experiments on air denser than the atmosphere, in which case a plate of tin was folded over the hole at the bottom, that it might be placed on a strong fire, the heat was then greatest below, and the long thermometer would mark upwards of 215° , while the short one stood at 209° or 210° . By desisting from blowing the fire, or removing a part of it, the particles of water suffering the greatest heat would ascend, mix with the rest, and for some little time make the whole column of an uniform temperature. But the fire being totally removed, the top of the column in cooling was always hottest; wherefore, in all these experiments, whether on dense or rare air, great care was taken to mix the water thoroughly.

From Mr. DE LUC's book it appears, that M. AMONTONS found the effect of heat on the air confined in his thermometer, which seems to have been the same sort of instrument with the manometer, proportionable to the weight with which it was loaded. By this he could not mean that, being of a double density, it had twice the expansion. I apprehend it must here be understood, that the spaces the air occupied, were inversely as the weights. That being pressed with a double weight, it only filled half the space; or with half the weight, a double space. This is no doubt nearly, though not accurately, the law that it follows. From these experiments it appears, that there is little difference in the actual expansion or elastic force of air, pressed with an atmosphere + or — one-third part: yet, when it is rendered extremely rare, its elasticity is wonderfully diminished. There seems likewise to be a visible diminution in its expansion, when loaded with two atmospheres and a half. Some of the tubes that I used were near nine feet

The total expansion 484.21 resulting from the third class of experiments, which are very consistent among themselves, being divided into parts proportionable to the manometrical spaces, as measured in degrees of the quicksilver thermometer, we have the expansions for intermediate temperatures, expressed at the bottom of the third table, where, it is to be observed, the rates for every 10° below 92° were found by interpolation.

Now as barometrical observations will probably never be made in a temperature higher than 92° in the shade, nor in one lower than 12° , if we subtract 26.038, the expansion answering to 12° , from 222.006, that which corresponds to 92° , we shall have 195.968 for the 80 intermediate degrees; or 2.45 for the mean rate on each. This equation, compared with Mr. DE LUC's, bears the proportion of 245 to 210, which is a difference of $\frac{35}{100000}$ on every degree, or one-seventh part of the whole: and though this rate will be found hereafter to

feet long. Had it been possible to have managed them of double or triple that length, so as to have admitted the air to be pressed with a column of 18 or 20 feet of quicksilver, I am persuaded the diminution in the expansion of air of that extraordinary density would have been much more perceptible.

Mr. AMONTONS found, that the condensation of air in his thermometers kept pace with that of spirit of wine, which we are told follows a decreasing progression with respect to quicksilver: wherefore his experiments agree with these, in making the condensation of air below 57° follow a decreasing progression, when compared with that of quicksilver.

exceed that deduced from the operations of the barometer in extreme temperatures; yet they agree exceedingly well with each other for the mean heat of the air, when the barometer will come most frequently into use.

The fourth class of experiments are all that now remain to be mentioned. The bare inspection of TABLE IV. will shew, how greatly superior the elastic force of moist is to that of dry air. It is true indeed, that two kinds of irregularities present themselves among the results: first, with regard to the total expansion for 212° ; and secondly, as to the greatest exertion of the elastic force, which sometimes seems to have taken place before the air has acquired the heat of boiling water. The first is easily accounted for: it must have arisen from different proportions of moisture being admitted into the same quantity of air, which there was no possibility of ascertaining, the bulbs and their apertures being of very different dimensions. With regard to the second irregularity, I am rather inclined to think that it may have proceeded from error of observation, it being difficult to determine the accurate temperature near boiling; especially when any part of the air rose above the top of the vessel, which was sometimes the case, notwithstanding its extraordinary height. Be that as it may, a very uniform increasing progression will be perceived to take place,
from

from the zero of FAHRENHEIT, as far as 152° or 172° ; and even to the boiling point, in those which I esteem the best experiments. By adhering to the mean result it will appear that air, however moist, having that moisture condensed or separated from it by cold, its expansion differs not sensibly from that of dry air. Thus the rate for 32° below freezing 2.22799, is nearly the same as in dry air; but no sooner doth the moisture begin to dissolve and mix with the air, by the addition of 20° of heat, than the difference is perceptible: for instead of 2.46675, the rate for 20° above 32° in dry air, we have 2.588 for that which is moist. In the next step of 20° , the rate for dry air is 2.5809; whereas that for moist is 2.97. In this manner the progression goes on continually encreasing, so as to give 7.86854 for the mean rate on each degree of the 212° , which is near three times and a half the expansion of dry air. And lastly, the rate for the 20° between 192° and 212° , is twice and one-half the mean rate, and about nine times that which corresponds to the zero of the scale: but if the comparison is drawn from the mean of the fifth, sixth, and ninth experiments, as being probably nearest the truth, the total expansion of moist, will be more than four times that of dry air; and the rate for the temperature at boiling,

will be nearly fifteen times that which corresponds to the zero of FAHRENHEIT.

I am aware it will be alledged, that the proportion of moisture admitted into the manometer in these experiments, is greater than what can ever take place in nature; and therefore, in order to be able to judge of the degrees of expansion the medium suffers in its more or less dense, and more or less moist states, that not only air near the surface of the earth, but likewise that found at the top of some very high mountain, should have been made use of. I grant all this: but on the other hand it must be remembered, that these experiments are very recently finished; that a good hygrometer (if such can ever be obtained) a great deal of leisure time, and the vicinity of high mountains, were all necessary for the carrying of such a scheme into execution.

It is for these reasons, and in hopes that other people will, sooner or later, investigate this matter still farther, not only by experiments made on the expansion of air, taken at different heights above the level of the sea in middle latitudes, but likewise on that appertaining to the humid and dry regions of the atmosphere towards the equator and poles, that I have been induced to hasten the communication of this paper. In the mean time having proved, beyond the possibility of doubt, that a wonderful
difference

difference doth exist between the elastic force of dry and moist air, I may be allowed hereafter to reason by analogy, on the probable effects this will produce, in measuring heights with the barometer; leaving it to others, much better qualified, to consider how far it will affect astronomical refractions. In the following section I shall therefore give an account of the barometrical observations made in Britain, and compare them with some others made in distant countries.

S E C T I O N III.

An account of the barometrical observations made in Britain, wherein they are compared with some others of the same kind made in distant countries.

THE revival of the inquiries into that curious and useful branch of philosophy, whereby vertical heights are determined to a great degree of exactness, by the pressure of the atmosphere alone, we owe to Mr. DE LUC; who hath undoubtedly removed many of the difficulties that formerly occurred in the application of the barometer, and thereby encouraged others to attempt to overcome, some part at least, of such as remain.

If the rule deduced from the observations on Saleve had been absolutely free from exceptions, and if there had not been particular points in the theory concerning which the ingenious author himself seems to have entertained doubts, it would probably have been universally adopted, without undergoing any very scrupulous investigation; but the observations made at Sun-rising on Saleve, gave results that were defective, or less than the real height. In certain cases, the equation for high temperatures, remote from the zero of the scale, appeared to follow a diminishing, and in others an increasing progression. Hence arose some causes of uncertainty, with respect to the specific gravities of quicksilver and air, and the relative expansion of one compared with the other; especially when the atmosphere happened to have more or less moisture dissolved in it. It was doubtless from considerations of this sort, that Mr. DE LUC, in his book, so strongly recommends the making of numerous sets of observations, in different countries; that, by the united labours of all, this interesting part of natural philosophy, might be brought still nearer to perfection.

With this general object in view, I am now to give an account of the principal barometrical observations that have been made in Britain, on heights determined geometrically with great care. These heights are classed in
the

the following list in six sets, according to the districts of the country wherein they are situated, and nearly in the order of time in which the observations were made.

		Height in feet.
N ^o 1. Heights in and near London.	{ St. Paul's Church-yard (<i>g</i>), North-side, and iron gallery } over the dome, — — —	281
	Top of Paul's-stairs, and the said gallery, — — —	324
	Top of Scotland-yard wharf, and the dining-room of the Spaniard on Hampstead-heath, — — —	422
	Great Pulteney-street, and the said dining-room, — — —	352
	Pagoda in Kew gardens, — — —	116½
	Gun wharf in Woolwich Warren, and uppermost story of Shooter's-hill inn (<i>b</i>), — — —	444

(*g*) Mr. BANKS, assisted by other gentlemen, measured very accurately with a line the height of the ball of St. Paul's above the floor of the church, which was found to agree, exceedingly near, with that taken from the engraved section of the building. The distance of the ball from the dining-room of the Spaniard, was found by a base measured on Hampstead-heath; and their relative heights by the angle of depression of the ball, taken with the astronomical quadrant from the said dining-room. The heights of Paul's stairs and Scotland-yard wharf, with respect to each other, were found by measuring from them severally to the surface of high water in the Thames. And the relative heights of the church-yard and floor of the church with respect to the stairs, and of Pulteney-street with regard to the wharf, were obtained by levelling to them respectively.

(*b*) The height of Shooter's-hill inn, above Woolwich, was found by a base measured in the meadows from the Warren eastward. Lord MULGRAVE, Mr. BANKS, and Dr. SOLANDER, assisted in the geometrical operations; as did Dr. BLAGDEN, Mess. DE LUC and LLOYD, in the barometrical observations.

		Feet.
N ^o 2. near Tay- bridge in Perthshire.	Station at the East-gate of Castle Menzie's gardens } near the village of Weem, and top of Weem Craig, }	700 $\frac{1}{2}$
	The said station, and top of Bolfracks Cairn, —	1076 $\frac{1}{2}$
	The said station, and top of Dull Craig, —	1244 $\frac{1}{2}$
	The said station, and top of Knock Farle, —	1304 $\frac{1}{2}$
	The said station, and that at the rivulet of Glenmore, } below the South observatory on Schihallien, — }	1279 $\frac{1}{4}$
	The said station, and South observatory, —	2098
	The said station, and Western summit of Schihallien, } Station at the rivulet of Glenmore, and the South ob- } servatory, — — — — }	3281 818 $\frac{3}{4}$
N ^o 3. near Lanark.	Level of the Clyde at Lanark-bridge, and station in } the garden at Lanark, — — }	362 $\frac{1}{2}$
	Ditto level, and top of Stonebyre-hill, — —	654
	Robinhood's well, before Carmichael-house, and top } of Tinto, four feet below the summit of the Cairn, }	1642 $\frac{1}{2}$
	Ditto well, and West end of Carmichael-hill, —	451 $\frac{1}{2}$
N ^o 4. near Edin- burgh.	Leith pier-head, and top of the Calton-hill, —	344
	Leith pier, and summit of Arthur's Seat, — —	803
	Leith pier, and Kirk-yetton Cairn, on the East-end of } the Pentland hills, — — — — }	1544
	Calton-hill, and ditto Cairn, — — — —	1200
	Level of Hawk-hill study, and top of Arthur Seat, —	702 $\frac{1}{2}$
	Hawk-hill observatory, and bottom of the little rock } on Arthur Seat, $7\frac{1}{4}$ feet below the summit, — }	684
N ^o 5. near Lin- house.	Hawk-hill garden-door, and ditto little rock, —	730 $\frac{3}{4}$
	Linhouse, and East Cairn-hill, 5 feet below the summit, —	1176 $\frac{1}{2}$
	Ditto, 18 feet below the top, — —	1165 $\frac{1}{2}$
	Linhouse, and West Cairn-hill, 11 feet below the top, —	1178 $\frac{1}{2}$
	Ditto, and Corftown-hill, 4 feet below the top, —	386 $\frac{1}{2}$
	Corftown-hill, and West Cairn-hill, — —	792
N ^o 6. near Carnar- von in North Wales.	Ditto, and East Cairn-hill, — — — —	776 $\frac{1}{2}$
	Carnarvon Quay, and Snowdon Peak, — —	3555
	Ditto, and summit of Moel Eilio, — —	2371

To enter into a minute detail of the geometrical operations, whereby the whole of these vertical heights were

were determined, would be extremely tedious and uninteresting. That some idea may however be formed of the degree of accuracy with which they were ascertained, it will be sufficient to observe, that the requisite angles were taken with an astronomical quadrant of a foot radius, made by Mr. Sisson, and curiously adapted for the measurement of horizontal or base angles; which, as well as those of the vertical kind, might always be determined thereby to within ten seconds of the truth. The bases were measured with care; and, in order to ascertain the distances, the three angles of each triangle were, as often as possible, actually observed with the quadrant. That the variation of the line of collimation of the instrument, which was found to alter in carrying, might occasion no error, one or more of the angles of elevation, at each station, were taken on the arc of excess, as well as on the quadrantal arc. In all cases, the usual ⁽ⁱ⁾ allowances were made for curvature and refraction: and for the correction of the last, sometimes the angles of de-

(i) If the square of the distance be divided by the diameter of the earth, the quotient will give the curvature of the globe on that distance, or the excess of the apparent above the true level: and, by Mr. MASKELYNE's rule, the square of the distance being divided by the diameter of the earth, augmented by one-fourth part, we have the allowance for curvature and refraction; which last is supposed to raise the object, by an angle equal to that of a great circle subtended by one-tenth part of the distance.

pression as well as of elevation were taken. When time would permit, the geometrical operations were repeated at the first stations; or the angles of elevation were observed from some new point connected with the first, and whose relative height, with respect to the others, was known. Small altitudes were occasionally determined by levelling from one station to the other.

To prove that the vertical heights, assigned to the places in the preceding list, are exceedingly near the truth, I need only mention the following instances, by way of confirmation. In 1771, with the assistance of Dr. LIND and his friend Mr. HOY, I measured a base from the observatory of Hawk-hill westward, whereby the height of the summit of Arthur's Seat, above the telescope of the Hawk-hill quadrant, in its horizontal position, was found to be 685.66 feet. In 1775, these gentlemen levelled, three several times, from the summit downwards to the said telescope; and found the vertical distance to be, by the first operation, 686.47 feet; by the second, 684.43; and by the third, 685.25. This last, which, from the great care that was used, they considered as the best, differs only three-tenths of a foot from the geometrical result. They afterwards continued the operation of levelling from Hawk-hill to the pier of Leith, and having repeated it twice, with a difference of only two inches
between

between the results, they found the mean descent to be 117.38 feet: hence Arthur's Seat is above Leith pier, by the mode of levelling, 802.66; and by the mixed method 803 feet.

In 1774, when the astronomer-royal was carrying on the Society's experiments for ascertaining the attraction of Schihallien, I found, from my own geometrical operations, depending on a base measured in the plain near Taybridge, the Western summit of the mountain to be 1183 feet above the South observatory.

Of this height, the effect of curvature and refraction amounted to 28.86 feet, on the distance of Bolfracks Cairn from the observatory; and to 38 feet, on the distance of the said Cairn from the summit of Schihallien. The result of these operations I communicated to Mr. MASKELYNE, before his trigonometrical operations were begun. From the data which he hath since been so obliging as to furnish me with, depending on the base in Glenmore at the bottom of Schihallien, and the angles of elevation taken from the Southern extremity of that base, the Western summit of the mountain is 1186.6 feet above the South observatory. But if the triangle that served to connect the station of the barometer in that valley with the others, and the angles of elevation taken from the same station are made use of, the dif-

ference of height will be 1183.33 feet. Lastly, Mr. MASKELYNE's result, from the triangles on the North-side of the mountain, makes it 1180. The mean of these three 1183.51 feet, is the height of the Western summit of the mountain above the South observatory, which only exceeds my height by one-third of a foot. Here it is to be observed, that from the vicinity of these triangles to the mountain, and the shortness of the sides, the greatest curvature amounted only to 16 or 17 inches, which consequently made the effect of refraction next to nothing. This near agreement between the results seems therefore to prove, that the mode of computation for curvature and refraction, made use of in the Taybridge observations, is just.

By the first angles of elevation, taken from the station of the barometer in Glenmore, the Western summit of Schihallien is 2001.88 feet above it; from which, if we deduct 1183.33, there remains 815.55 for the height of the South observatory above the said station: but if the last angles of elevation at the station of the barometer are made use of, the height between it and the observatory comes out 818.97, whereof the mean is 818.76 feet. Though these instances are of themselves sufficient to prove, that the geometrical heights may be safely depended upon; yet, as an example of the method that

was always made use of, I shall annex to this paper, a plan of the triangles and detail of the operations for obtaining the height of Snowdon; because that mountain, at the same time that it is the highest I have measured, is, from its situation, more likely to be visited, and to have experiments repeated upon it, than the remote hills of the North. I now proceed to give some account of the barometrical observations.

The heights in and near London being so very inconsiderable, it was easily foreseen, that nothing conclusive could be drawn from observations made on them alone. It was, however, natural enough to try, even on these, whether the rule we had been furnished with would answer? A small height of 41 feet 4 inches, which, without inconveniency, could be recurred to at all times of the day, and all seasons of the year, was the first that was made use of. St. Paul's, Hampstead, Kew pagoda, and Shooter's-hill, were the next. The mean results of many observations on the three first, and of several on Shooter's-hill, were found to be defective. In general the coldest observations, made in the morning and evening, when the temperatures at the two stations differed least from each other, answered best. In the hottest part of the day, when that difference was the greatest, the results were most defective.

Some months spent in Scotland in the summer of 1774, afforded opportunities of making barometrical observations on hills of various heights, from three or four hundred, to upwards of three thousand feet, as hath been exhibited in the preceding list. That season was remarkably cold and wet; wherefore, in these observations, the mean temperature of the air in the shade was commonly about 55° . The hottest never exceeded 63° in the plain; and the coldest, namely those on the highest mountains, were generally from 43° to 48° .

From the defect found in the results of these observations, which, with respect to temperature, correspond to the mean and hottest of those made at Sun-rising on Saleve, and without any exception whatever, I could easily discover, either that a much greater equation than what the rule directed, must be applied for each degree of heat above the zero of the scale; or, that the zero itself would fall considerably lower than $39^{\circ}74$, where Mr. DE LUC's formula, adapted to English measures, hath fixed it. This first step towards a correction of the rule, naturally pointed out the second thing to be aimed at, namely, the obtaining of a sufficient number of cold observations, near the zero, and as far as possible below it, that the equation might disappear entirely, and even come to be applied with the contrary sign. Of this kind the winter seasons

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seasons of 1774 and 1775 afforded a few on the small heights in and near the metropolis; but the best I have been furnished with are those which Dr. LIND, assisted by Mr. HOY, was so obliging as to make on Arthur's Seat near Edinburgh; and those which Captain CALDERWOOD has since favoured me with on the Cairn-hills, being a part of the Pentland range to the South-west of that city.

By comparing these sets of observations together, it appeared from all of them, that when the air was at or near the freezing temperature, the logarithmic differences gave the real height, in English fathoms and thousandth parts, without any equation; and when considerably below that point, the equation was to be subtracted, or applied with the sign — instead of +. It was farther perceived, that the same general conclusion might be drawn from the coldest, not only of the Sun-rising, but even of the ordinary observations on Saleve; some reduction of the temperature being in certain cases made, on account of the exposure of the thermometer to the Sun's rays: hence I was led to suppose, that the morning observations, instead of being made exceptions from the rule, were those, which, it might be presumed, would form the best basis for deducing the equation depending on the heat of the air; because the mean temperature of the column was then found to differ least from that of its
extre-

extremities; whereas in the hottest time of the day, that difference was generally the greatest.

Having been enabled, by means of the cold observations, to form some judgement whereabouts the zero of the scale would fall, below which the equation was negative, and above it affirmative; it followed of course, that the next principal thing to be sought for, was the maximum of equation, or that corresponding to the highest temperatures the climate of our island would afford. It was partly with the view of obtaining these that I went, in July 1775, to Snowdon in North Wales. On this expedition Captain CALDERWOOD was so obliging as to accompany me, and lend me his assistance in the operations for determining the geometrical height of that remarkable mountain. At that particular period, the weather proved unfavourable for obtaining hot barometrical observations; but, in other respects, they were very satisfactory, as being in general consistent among themselves, and agreeing sufficiently near with those of the preceding year in Scotland; at the same time that they were made on a height, as formerly mentioned, greater than any other hitherto measured, with equal care, in Britain. During the summer of 1776, Dr. LIND obtained some more hot observations on Arthur's Seat; and in the beginning of the following winter, Captain CALDERWOOD

made others of the cold kind, on the Cairn-hills in his neighbourhood. From the combination of the whole of these observations taken together, and a comparison of them with Mr. DE LUC's, as far as they are similar, I mean to shew the agreement or otherwise, between the equation for the heat of the air, as deduced from the barometer and manometer; but since the British observations, in certain cases, differ considerably in their circumstances from those on Saleve, it is necessary, in the first place, to point out wherein this difference chiefly consists.

In the observations in Britain, the barometers and detached thermometers have been, almost constantly, placed in the open air in the shade, and suffered to remain there generally half an hour, and sometimes a great deal longer, before the corresponding observations were begun, that the quicksilver might have time to take the temperatures of the situations respectively. They were then observed four times, usually at intervals of ten minutes, the mean of the four being that which is calculated, and called a single observation. If the time did not admit of so long an interval, the same number of observations were taken at distances of five minutes from each other. In either case, the extremes never differed above a few thousandth parts of an inch from the mean, so as to

render the computations of them separately wholly unnecessary.

Except in very small heights, and chiefly in London, where it was impossible to screen the upper barometer so effectually from the Sun during the time of observation as that below, which generally stood in the shade of some building, the temperature of the quicksilver in the superior ^(k) hath been colder than that in the inferior barometer. The difference was commonly found to be two or three degrees; sometimes it would amount to six or seven; rarely, in heights that were considerable, to nine or ten; and in one instance only to thirteen, where the vertical distance of the instruments was great.

Whether in the plain or on the tops of the highest mountains, the detached thermometers, indicating the temperature of the air, have generally stood something

(k) I have sometimes found, particularly in frosty weather, that a thermometer placed on the pavement of the North-side of St. Paul's Church-yard, close to the wall of the building, would stand two degrees lower than that which was exposed on the North-side of the iron gallery over the dome. The first, no doubt, felt the cold produced by the evaporation from the stones, while that above might be affected by the ascending smoke. But the most remarkable instance of this kind occurs in one of Dr. LIND's observations, on the breaking up of the hard frost January 31, 1776: at Hawk-hill, at 10^h 45'' A.M. the temperature of the open air was 14°, while that at the summit of Arthur's Seat was 20°. The frost that remained in the ground kept the air extremely cold below, though it had already felt the effects of the thaw at the top of the mountain.

lower

lower than those attached to their respective barometers, until they had remained a considerable time in the same situation, equally shaded from the Sun, when they always agreed: whence it followed, that in these observations, the mean temperature of the air, and equation depending upon it, might always have been determined very near the truth, from the temperature of the quicksilver in the tubes, as shewn by the attached thermometers, without ever consulting the detached ones. Let us now see what were the circumstances attending the observations on Saleve.

Mr. DE LUC's lowermost barometer stood in the ground-story of a house near Geneva, where it remained unaltered during the whole of his experiments; while the detached thermometer, indicating the temperature of the air, was exposed on a small eminence, at a little distance, directly to the Sun's rays: hence we find that, in the observations of high temperatures, the bottom of the column of air is often 12° or 15° , and in one case 18° , hotter than the quicksilver in the tube. And even in the lowest temperatures, the bottom of the column of air is generally hotter than the quicksilver within doors, contrary to common experience in this country: for in England, in winter, the exterior air in the shade is always colder than the interior air. This circumstance gives

reason to apprehend, that the thermometer suffered not only direct but reflected heat.

The superior barometer was shaded with a parasol from the Sun, while its corresponding detached thermometer was exposed to his rays: wherefore, in the observations of high temperatures, the top of the column of air is usually four or five degrees hotter than the quicksilver in the barometer standing in the same air; and the mean heat of the column often exceeds very considerably the mean heat of the quicksilver in the tubes.

In many of the coldest of Mr. DE LUC's observations, as well as in those of mean temperatures of about 50° or 55° , the superior barometer is often the hottest of the two, even when the surrounding atmosphere at the top is colder than at the bottom. This circumstance is easily accounted for: wood is known to be a bad conductor of heat, to receive it slowly, and retain it long: that barometer, which was moved about from place to place upon the mountain, with a very short interval between the observations (as is sufficiently evident from the great number of stations it passed through in a limited time) must have acquired and retained heat superior to that of the atmosphere, and communicated it to the tube with which it was in contact. Some difference would no doubt arise from this cause, if the temperatures of the
quicksilver

quickfilver in the tube and attached thermometer did not keep exactly pace with each other.

The last point to be mentioned is still more remarkable than the rest; it is briefly this: in the observations at Sun-rising on Saleve, though the superior quickfilver is the coldest; yet the top of the column of air is commonly five or six, and sometimes eight or nine degrees, warmer than the bottom.

Having thus shewn the steps that were taken, for obtaining the coldest and hottest barometrical observations that the climate of this island would afford, the mode of observing, and wherein the circumstances attending them differed from those on Saleve, I shall now point out the general result. In order to avoid repetitions as much as possible, it is necessary, once for all, to remark, that the computations of the British observations, by the rule hereafter to be given, are subdivided into their respective classes. Each table contains 15 columns, which their titles sufficiently explain, that the principles from which the rule was deduced, the result and error, might all appear in one view. The last column towards the right-hand shews the ratio of the weight of quickfilver to air, the columns of the first in the barometers being severally reduced to the mean temperature of the last.

By comparing the tables it will be found, that the observations for extreme temperatures belong to the Edinburgh class of observations (N° 4.) it being thought best, in this case, to omit the few hot ones obtained on the inconsiderable heights near London: the mean of the coldest, answering to the temperature of $21^{\circ}.75$, make the logarithmic excess $\frac{29}{1000}$; and the mean of the hottest, corresponding to the temperature of $69^{\circ}.6$, give a defect of $\frac{81}{1000}$. Now the sum of the two equations $\frac{110}{1000}$, being divided by the difference of temperature $47^{\circ}.85$, we have nearly 2.3 for the mean rate of the equation on each degree, which is less than that resulting from the operations of the manometer. Again, from the mean of the very best observations, as being made on the greatest heights, when the temperature of the air is 52° , it appears, that the defect is from $\frac{49 \text{ to } 50}{1000}$, or 2.5 for each degree nearly, which agrees perfectly well with the manometrical expansion. In this case, the ratio of the weight of quicksilver to air is as 11377 to 1; greater very considerably than 11232 to 1, assigned to them by Mr. DE LUC, when the temperature is $69^{\circ}.32$, answering to the zero of his scale, without any allowance for the diminution of pressure on his columns, which should have rendered air still comparatively lighter. From the British observations, made on the most considerable heights,

it appears, that when the temperature of the air is $28^{\circ}.2$, the ratio of its weight, with respect to that of quicksilver, is as 1 to 1.0552: hence the increase of the weight of air, on every degree of difference of temperature between $28^{\circ}.2$ and $52^{\circ}.5$, amounts to 34.4; and hence we have $52^{\circ}.5 - 28^{\circ}.2 = 24^{\circ}.3$ for the temperature of the air in Britain, when its weight would be $\frac{1}{1.1232}$ of that of quicksilver; and consequently agree with Mr. DE LUC's, though the heat would differ from his 21° . It will no doubt be remarked, that the equation for the air, resulting from the operations of the barometer, falls short of that given by the manometer. Part of the difference, I apprehend, may arise from the small number of barometrical observations obtained in extreme temperatures. I shall, nevertheless, adduce reasons hereafter for supposing, that it really should diminish, because of the drier and less elastic state of the superior air, compared with that taken into the manometer at the earth's surface. In the mean time, since both instruments agree in the equation for 52° , which is a heat that the barometer will very frequently be used in, it seems best to adhere to the mean manometrical result 2.45, in fixing the zero of the scale, which is obtained in the following manner.

Divide the excess or defect, expressed in 1000th parts of the logarithmic result, by 2.45, the mean expansion of
air

air for each degree of the thermometer; the quotient will give the number of degrees, in the first case, to be added to, and in the last subtracted from, the temperature of the air in the observation; the sum or difference answers to the zero of the scale, or that temperature when the logarithmic result gives the real height in English fathoms and 1000th parts.

According to this mode of computation, we have, from the aggregate of the several classes of British observations, the place of the zero as follows:

				Zero.	
By the 1st class of observations in and near London, } between the temperatures of — —				° 25.5 and ° 71.2 at ° 32.2	
2d, near Taybridge,	—	—	46.1	— 62.9	— 31.1
3d, near Lanark,	—	—	44.	— 62.	— 32.8
4th, near Edinburgh,	—	—	17.	— 70.7	— 31.3
5th, near Linhouse,	—	—	26.1	— 46.5	— 29.9
6th, near Carnarvon,	—	—	49.1	— 62.3	— 32.9
Mean place of the zero at — —					<u>31.7</u>

The number $31^{\circ}.7$ differing so very little from 32° , we may hereafter consider that remarkable point of FAHRENHEIT's thermometer, as the zero of the scale depending on the temperature of the air; and hence is deduced the second part, of the rule for measuring heights with the barometer. When the mean temperature of the column of air to be measured is at 32° of FAHRENHEIT, the difference

difference of the common logarithms of the equated heights of quicksilver in the inferior and superior barometers, expressed in 1000th parts of an inch, gives the real height in fathoms and 1000th parts, the three figures towards the right-hand being decimals, and the rest integers; which, being multiplied by six, gives the result in feet.

Let us next consider, in a general way, how far this will correspond, or otherwise, with Mr. DE LUC's observations in extreme temperatures.

I have already had occasion to remark, that when the temperature of the air was at $69^{\circ}.32$, as indicated by thermometers exposed to the Sun's rays, Mr. DE LUC found that the differences of the common logarithms of the heights of the barometers at the two stations, gave the altitude between them, in French toises and 1000th parts: in which case the specific gravity of quicksilver to air was as 11232 to 1. When his formula is adapted to English measures, the zero of the scale necessarily descends to 39.74, where the English fathom bears the same proportion to the modulus of the common logarithms, as, in the former case, the French toise did to that modulus, the equation for the intermediate temperature being now applied with the contrary sign. As it hath been shewn, that the British observations differ in their

circumstances from those on Saleve, and require a greater equation, it is unnecessary to enter into any minute comparison of the two sets: nevertheless, that some idea may be formed of the cause, of part at least, of the difference that takes place between them, I have collected into one view, the computations of such as were made in extreme temperatures; namely, the coldest of those at Sun-rising (though the whole of that class were considered as exceptions from the rule); the coldest and hottest of the ordinary observations; also those on the Dole⁽¹⁾, at Genoa, and at Turin, whereby the heights of the lake of Geneva and of Turin, above the sea at Genoa, were obtained. In the table it will be observed, that there is a column for the reduced temperature of the air, on account of the exposition of the thermometer to the Sun's

(1) Having recomputed the whole of Mr. DE LUC's observations on Saleve, and classed them according to the months in which they were made, I intended, at one time, to have given a general table, comprehending the mean results of all of them: however, this is now become unnecessary, since a very respectable and ingenious member of this Society hath had opportunities of making many curious and interesting observations on those very heights, which cannot fail of being perfectly satisfactory; and who, at my request, was so obliging as to determine the height of the Dole geometrically. On this mountain Mr. DE LUC had made barometrical observations, whose results differing considerably from the altitude, 4182 feet above the lake of Geneva, as taken by Mr. FATIO DE DUILLIER, made me suspect there was an error. In fact it appears, from the last measurement, that the summit of the Dole is 4293 feet above the surface of the lake, which gives for the vertical distance of Mr. DE LUC's barometer 4210 feet.

rays: I apprehend that I have not exceeded, but rather fallen short, in the reduction, to what would have been indicated by thermometers in the shade, perfectly free from direct and reflected heat, and with sufficient time allowed between the observations. Be this as it may, it is of no importance, as no other conclusion is drawn from these observations, than that of shewing what, in my apprehension, might probably have been the case, if another mode had been adopted.

From the table it appears, that when the temperature of the air is at $29^{\circ}.5$, the logarithmic excess is $\frac{9}{1000}$; and at $75^{\circ}.5$ reduced temperature, the defect is $\frac{96}{1000}$. The sum of the two equations $\frac{105}{1000}$ being divided by the difference of temperature 46° , we have, as in the British observations, nearly 2.3 for each degree, which is greater than that applied by Mr. DE LUC's rule, in the proportion of 23 to 21. That too small an equation hath been made use of in these hottest observations, supposing the original zero and temperature to remain, is sufficiently evident: for $\frac{96}{1000}$ being divided by 42° the difference of temperature, we have, as before, 2.3 very nearly for the equation answering to each degree.

Farther, if we consider the ratio of the weight of quicksilver to air, actually resulting from the observations themselves, the same kind of error (for I cannot see

it in any other light) still exists. Thus, in the coldest of the morning, as well as in the ordinary observations, when the temperature is at or near freezing, the mean ratio of the weight of quicksilver to air, is about 10850 to 1. When the observed and reduced temperatures are respectively 41° and 35° , the ratio between them is that of 11295 to 1, answering nearly to what hath been assigned to them when the heat is $69^{\circ}.32$. Again, in the hottest observations of the 14th and 15th of July 1759, and 20th of July 1760, on the highest, and consequently the best stations, when the observed and reduced temperatures are respectively $81^{\circ}.7$ and $75^{\circ}.6$, quicksilver is to air as 12650 to 1. Now if we reduce this number 12650 by a proportionable part, for the degrees of difference between Mr. DE LUC's zero $69^{\circ}.32$, and the observed and reduced temperatures respectively, we shall have, in the first case, 12200; and in the last, 12390 to 1, for the ratio of the weight of quicksilver to air; either of which exceeds very considerably 11232, which hath been assigned to them.

With regard to the observations on the Dole, the defect is $\frac{81.4}{1000}$, answering to the observed temperature of $66^{\circ}.6$, and which is only reduced to $65^{\circ}.2$. On this great height, the ratio of the weight of quicksilver to

air^(m) is that of 12595 to 1. Mr. DE LA CAILLE's observations at the Cape of Good Hope, annexed to the table containing Mr. DE LUC's, give a defect of $\frac{18.7}{1000}$, when the temperature seems to have been about 58°, in which case quicksilver was 11687 times heavier than air.

Now if, from the aggregate of these observations, the same method be adopted, as was made use of in the British, for finding the zero of the scale, we shall have it as follows:

By Mr. DE LUC's equation for the air and observed temperature.				By the manometrical equation and reduced temperature.			
Coldest of the morn- ing observations, } from —	°	°	°	from 25.2 to 30.5 at	°	°	°
	25.2	to 30.5	at 33.7		25.2	to 30.5	at 33.12
Coldest of the ordi- nary observations, } —	27.1	— 41.9	— 38.7	—	26.	— 35.	— 32.97
Hottest of the ordi- nary observations, } —	76.	— 84.5	— 36.2	—	73.5	— 77.	— 36.32
On the Dole, —	59.2	— 71.5	— 27.6	—	58.	— 70.	— 32.
Light house of Genoa, —	75.	— 79.	— 26.	—	75.	— 79.	— 33.40
DE LA CAILLE's, —	—	58.	— 30.	—	—	58.	— 33.35
Zero at — —	—	—	32.03	Zero at — —	—	—	33.52

(m) It will even be found, though the calculations are not inserted in the table, that the hottest of Mr. DE LUC's morning observations, June 8th, 1758, at the 15th station, answering to the mean temperature of 57°.5, and which I consider as the best, because no reduction is necessary for the exposition of the thermometer, agree with the manometrical experiments, in requiring a greater equation than is wanted in extreme temperatures: for in this case, the mean of two observations gives a defect of $\frac{65.5}{1000}$ for 25°.5 above freezing, which is 2.57 for each degree; the ratio of the weight of quicksilver to air being that of 12196 to 1.

From

From the mean of these observations, though the results are irregular among themselves, it appears sufficiently evident, that if the morning observations on Saleve had been retained, instead of being made exceptions from the rule, the zero of the scale would have descended about 8° ; *viz.* from $69^{\circ}.3$ to $61^{\circ}.4$ of FAHRENHEIT, supposing always the equation 2.1 for each degree of temperature, and the French toise, as the standard measure, to have been adhered to: for the French toise bears to the English fathom, the proportion of 106575 to 100000; wherefore $\frac{6575}{106575} = \frac{61.69}{2.1} = 29^{\circ}.4 + 32^{\circ} = 69^{\circ}.4$, denotes the relative positions of the two zeros, the intermediate equation $\frac{61.69}{1000}$ being to be subtracted, when the toise is made use of. But it hath been shewn, that the mean expansion of air is really greater, for such temperatures at least as the barometer can be applied in, than what Mr. DE LUC supposed it, in the proportion of 245 to 210; whence it follows, that $\frac{61.69}{2.45} = 25^{\circ}.18 + 32^{\circ} = 57^{\circ}.18$, will denote the relative positions of the two zeros; which, instead of almost 30° , are only distant from each other a little more than 25° .

From what hath been said it is easy to see, that in calculating heights according to Mr. DE LUC's rule, when the temperature of the air is below his zero, which we
 may

may take at 40° , the English measure being used, the common error in the result will be equal to the sum of the two equations, $2.1 + 2.45 = 4.55$ for each degree; which amounts to $\frac{36.4}{1000}$ parts for the 8° that the zero is too high. Above 40° , the former error $\frac{36.4}{1000}$ will be augmented by the difference of the equations for each degree that the temperature is above his zero, *viz.* $2.45 - 2.1 = \frac{0.35}{1000}$. In either case it is to be observed, that the progressive rate of equation for the heat of the quicksilver is not here taken into the account; because it will not produce any material difference, unless one barometer is much hotter than the other, at the same time that their vertical distance is very great. Thus the 32d degree of FAHRENHEIT, or freezing temperature, which is fundamental in all thermometers, happens, somewhat remarkably, to be the zero of the scale, when the English fathom bears such proportion to the modulus of the common logarithms, as that their difference, in computing heights by the barometer, brings out the result in fathoms. No other proportion of a measure will do it: for if we suppose twenty-four of different lengths, between ours and the French toise, each surpassing the other by $\frac{2.63}{1000000}$ of that toise, the zero of the scale, in computing heights by these measures respectively, will ascend a single de-

gree on each; and the French toise being the 25th, will have its zero nearly at the 57th degree: about which temperature the expansion of air appears, from the experiments, to be at its maximum. From that point, therefore, the equation will diminish both ways, though by a quicker progression for condensation, than it doth for dilatation.

Having thus compared, in a general way, the results of the British observations with those of Mr. DE LUC, pointed out what seem to be the chief causes of the constant defect found in his rule, and thereby obtained, it is hoped, some corrections tending to improve the theory of the barometer, when applied to the measurement of heights in middle latitudes; it remains to shew the principles, whereon the table for the equation of the air hath been constructed. Previously however to this, it may be proper to compare, with as much brevity as possible, these observations, with others that have been made towards the Pole and at the Equator: from which it will appear probable, that the rule which answers in middle latitudes, will not in the frigid and torrid zones.

In 1773, Captain PHIPPS, now Lord MULGRAVE, commanding two of his Majesty's ships then sent on discoveries towards the North Pole, measured geometrically, with great care, the height of a mountain in Hakluyt's Island

near

near Spitzbergen, and found it to be 1503 feet above the level of the sea. On the morning of the 18th of August, the following observations, at the sea-shore and top of the mountain, were made with a single barometer, wherein the quicksilver had not been boiled.

At 6 h. A.M. Barometer at the shore,	—	—	30.040	therm. 50°
7 h. 45' A.M. Ditto at the top of the mountain,			28.266	— 42
8 h. 45' A.M. Ditto at the top of ditto,	—		28.258	— 42
11 h. 45' A.M. Ditto at the sea-shore,	—		30.032	— 44

Whence we have the following computations, equated for the times corresponding to the two observations at the top.

$$\begin{array}{rcl}
 7 \text{ h. } 45' \left\{ \begin{array}{l} 30.038 \\ \text{A.M. } \left\{ \begin{array}{l} 28.266 \end{array} \right. \end{array} \right. & \begin{array}{l} 46^\circ - 046 = 29.992 \\ 42 - 031 = 28.235 \end{array} & \left. \right\} = 1573 \quad \left\{ \begin{array}{l} + 70. \\ = 44.5 \end{array} \right\} \begin{array}{l} 43^\circ \\ 41 \end{array} \left. \right\} 42^\circ \\
 8 \text{ h. } 45' \left\{ \begin{array}{l} 30.036 \\ \text{A.M. } \left\{ \begin{array}{l} 28.258 \end{array} \right. \end{array} \right. & \begin{array}{l} 45^\circ - 043 = 29.993 \\ 42 - 031 = 28.227 \end{array} & \left. \right\} = 1581.3 \quad \left\{ \begin{array}{l} + 78.3 \\ = 49.5 \end{array} \right\} \begin{array}{l} 43 \\ 41 \end{array} \left. \right\} 42
 \end{array}
 \left. \vphantom{\begin{array}{l} 7 \text{ h. } 45' \\ 8 \text{ h. } 45' \end{array}} \right\} \begin{array}{l} \text{Quicksilver to air as} \\ 10224 \text{ to } 1. \end{array}$$

$$\begin{array}{rcl}
 \text{Mean} & \frac{1577.1}{1000} & = \frac{+47}{1000}
 \end{array}$$

From these observations it appears that, instead of the usual equation $\frac{24.5}{1000}$, to be added to the logarithmic result, in order to obtain the true height in Britain, when the temperature is 42° , there is an excess of $\frac{47}{1000}$: and, instead of the usual ratio of the weight of quicksilver to columns of air, of equal altitude and temperature in Britain, namely about 11200, we have that of 10224 to 1.

Thus air at Spitzbergen seems to be specifically heavier, than that affected with the same heat and pressure in the middle latitudes: whence it follows that, instead of 32° which is found to be the zero of the scale about the middle of the temperate zone, we shall have $\frac{47}{245} = 19^{\circ}.2 + 42^{\circ} = 61^{\circ}.2$ for the zero at Spitzbergen, within 10° of the North Pole.

It is much to be regretted, that the French academicians, when employed in measuring the degrees of the meridian in Peru, were not supplied with better barometers, and that they made not observations at corresponding times; since the scene of their operations was undoubtedly preferable to any other on the surface of the globe, for determining many curious points with respect to the modifications of the atmosphere in the torrid zone: nevertheless, by attending diligently to what Mr. BOUGUER ⁽ⁿ⁾ hath told us, of the steadiness of the barometer

(n) He says, that at the South Sea, REAUMUR's thermometer, in the morning before Sun-rising, stood at 19° , 20° , or 21° ; and in the afternoon at 26° , 27° , or 28° . The respective means correspond to $76^{\circ}\frac{1}{2}$ and $92^{\circ}\frac{1}{2}$ of FAHRENHEIT, and make the mean heat of the day $84^{\circ}\frac{1}{2}$. At Quito the temperature continued at 14° or 15° , answering to $65^{\circ}\frac{1}{2}$ of FAHRENHEIT. At the summits of Coraçon and Pichincha, the thermometer stood in the morning several degrees below freezing, and varied 17° in the heat of the afternoon; whence the mean temperature at these highest stations, would probably be about $43^{\circ}\frac{1}{2}$ of FAHRENHEIT. He farther says, that in the torrid zone, whatever may be the mean

meter throughout the year; the uniformity of the mean temperature in every assigned station; and his mode of computing, by means of the tables of common logarithms, the altitudes of the Cordillero mountains above the valley that extends itself between them; it will be no difficult matter to discover, nearly at least, what sort of equation became necessary; and what were the relative weights of quicksilver and air of the mean temperature, not only in that high region of the atmosphere, but also at the level of the sea.

Thus, by inspecting the table of computations, it will appear, that columns of air, whose bases were removed six or eight thousand feet from the level of the sea, and whose heights equalled that distance, when the temperature was 55° of FAHRENHEIT, as determined from the mean between the coldest of the morning and hottest of the afternoon, the mean logarithmic defect was only $\frac{56.3}{1000}$: whereas, in measuring heights near the level of the sea, in middle latitudes, the common equation for that temperature is about $\frac{57}{1000}$. The mean ratio of the weight of quicksilver to air, on these long columns comprehended respectively between Carabourou and Quito, and the

mean heat in any assigned station, it continues uniformly the same throughout the year. In this rough estimation of the temperature in Peru, it seemed unnecessary to examine, whether the true thermometer of REAUMUR was used or not; as it could produce no material difference, except at the very hottest stations.

summits of Pichincha and Coraçon, is that of 16793 to 1. On the altitude of 1534 feet, intercepted between Carabourou and Quito, which short section of the column is about half-way between the level of the sea, and the summits of the Cordilleros, the mean temperature being 66°, the ratio is that of 15089 to 1: hence it seems probable, that quicksilver would have to the different sections of the general column of air, comprehended between the sea and the top of Coraçon, nearly the following ratios:

	Temp.	
At the level of the South Sea,	$84\frac{1}{2}$	13100 to 1
Half-way from thence to Carabourou,	$75\frac{1}{2}$	14100
At Carabourou, — —	$66\frac{1}{2}$	15100
Half-way from thence to Coraçon,	55	16100
At the summit of Coraçon, —	$43\frac{1}{2}$	17100
Whereof the mean is, —	65	15100

Mr. BOUGUER tells us, that the barometer in the torrid zone varies not at the sea-shore above two and a half, or at most three lines throughout the whole year. At Popayan, its variation is only a line and a half; and at Quito a single line. Now let us suppose, that an altitude had been measured with the barometer at the level of
the

the South-sea, where the descent of quicksilver at the upper station was exactly an inch in the mean heat of the day, answering to $84^{\circ}\frac{1}{2}$. On the former supposition of the weight of quicksilver to air, the height would be 13100 inches or 1091.7 feet.

$$\text{Hence } \left\{ \begin{array}{l} 29.930 \quad 84^{\circ}\frac{1}{2} - 169 = 29.761 \\ 28.930 \quad 84^{\circ}\frac{1}{2} - 169 = 28.761 \end{array} \right\} = 890.6 \text{ feet,}$$

the logarithmic result, which is defective 201.1, or nearly $\frac{226}{1000}$ parts. Now this equation being divided by 2.45 the mean expansion of air, we have nearly 92° for the difference between $84^{\circ}\frac{1}{2}$, the temperature of the observation, and the zero of the scale, which reduces it to $-7^{\circ}\frac{1}{2}$ of FAHRENHEIT. If it should be thought that I have supposed the air to be too light at the level of the sea under the equator, let it be taken to quicksilver only, at a mean between 13100 and 12672, which seems to have been the ratio of their weights at Genoa, when Mr. DE LUC's temperature was 79° , and we shall have 12881 inches, or 1073.4 feet of air, for the counterpoise to the inch of quicksilver in the barometer: hence $1073.4 - 890.6 = \frac{182.8}{890.6} = \frac{205}{2.45} = 83^{\circ}.7$, will denote the number of degrees that the zero of the scale would, in that case, be below the temperature of the air, which brings it to within less than a degree of the cypher of FAHRENHEIT. But in middle latitudes the zero of the scale is at 32° , and the

equation, applicable at the level of the sea for the heat of $34^{\circ}\frac{1}{2}$, is at most only $\frac{132}{1000}$ instead of $\frac{205}{1000}$.

Mr. BOUGUER found, that the rule which his experience had furnished him with, for computing heights with the barometer between the ranges of the Cordilleros, namely, that of deducting $\frac{1}{30}$ th part from the number of toises expressed by the logarithmic differences, which agrees nearly with the equation $\frac{36.3}{1000}$ which I have made use of in the table of computations, would not answer when he came to apply it at the level of the sea. He tells us, indeed, that the elasticities of the air, above and below, are there, as well as in Europe, exactly proportionable to its condensations; and even, that the intensity of the elastic force, or spring of the air, is every where equal in all places of the torrid zone that are considerably elevated. The real condensations in each place are proportionable to the weights of the superior columns causing the compression; these condensations being in geometrical, the heights are in arithmetical progression. But below the same law doth not take place; because the intensity of the elastic force is really considerably less at the level of the sea, than it is at one or two hundred toises above it, notwithstanding the effect of the heat, which should render it greater. It is to be observed, that Mr. BOUGUER hath not given us the observations whereon
he

he founded this last deduction; and his note on the text, which I apprehend, nevertheless, conveys his true meaning, is contradictory to it: for there he says, that the dilatation occasioned by the heat throughout the day, changed the distribution of the weight with regard to all the places situated within the Cordilleros, as well as on other mountains, and made the lower sections of the columns contain less and the upper sections more air, than they should have done, had it been a perfectly elastic fluid.

Having now mentioned all the barometrical observations that have come to my knowledge, tending any way to throw light on this very intricate subject, it remains to sum up, from the whole, the general principles whereon I have proceeded in constructing the table of equation for the heat of the air.

It will be remembered, that I have more than once remarked, that in the British observations, when the temperature was 52° , the defect was $\frac{49 \text{ or } 50}{1000}$, the lowermost barometer standing at or near the level of the sea; but in the observations on Tinto, a considerable hill appertaining to the third class, whose base is elevated 700 feet above the level of the Clyde at Glasgow, when the temperature was 52° , I found the equation to be little more than $\frac{45}{10000}$. Again, these two facts being compared with

the aggregate result of Mr. DE LUC's observations, where the lowermost barometer stood about 1300 feet above the sea, the equation for the same temperature seemed not to exceed $\frac{4.2}{1000}$. Lastly, these circumstances being confronted with the results of Mr. BOUGUER's observations, where the lowermost barometer stood from 6000 to 8000 feet above the sea, the mean equation for 55° was only $\frac{36.3}{1000}$, which gives $\frac{34}{1000}$ for the heat of 52° . Now these Peruvian observations, which I believe to be exceedingly good from the steadiness of the barometer in that part of the world, being substituted in lieu of those not yet obtained in our own quarter of the globe, there seemed to me to be a necessity for concluding, that the equation for middle latitudes, with any assigned temperature above or below the zero of the scale, diminished as the height of the place above the sea increased; which consequently implied, that the magnitude of the logarithmic terms increased faster than the dilatations of the air. But when the comparison was carried yet farther, and the observations in Peru and at Spitzbergen were fairly brought into one view, there appeared to be sufficient grounds for suspecting, if not absolutely for concluding, that there could be no fixed zero for the scale depending on the temperature of the air; but that it would change with the density of the atmosphere appertaining to the latitudes,

latitudes, climates, or zones of the earth, where the observations were made. On this supposition it was natural for the mind to form to itself some general hypothesis, which might serve to account for the appearances; and the first that presented itself was the following: that the atmosphere surrounding our globe might possibly be composed of particles, whose specific gravities were really different; that the lightest were placed at the equator; and that the density of the others gradually increased from thence towards the poles, where the heaviest of all had their position ^(o)

It is a well known and established fact, that in the middle latitudes, a North or North-east wind constantly raises the barometer, and generally higher as its continuance is longer. The contrary happens when a South or South-west wind blows; for I believe it is commonly lowest when the duration and strength of the wind from

(o) It was suggested by Dr. GEORGE FORBYCE, that equatorial and Greenland air might be brought bottled up, and weighed in this country in air of the respective temperatures, by means of a curious balance whereof he is possessed, in order to see whether any difference could be discovered in their specific gravities. A thought of the same kind, but more easily put to experiment, occurred to Lieutenant GLENIE, of the Royal Artillery, namely, that of weighing equatorial and polar sea-water. To this gentleman I am obliged for his assistance in part of the manometrical experiments, as well as in several of the computations.

that quarter have been the greatest. Thus the North-east wind, by blowing for any length of time, brings into the middle latitudes a mass of air heavier than that which naturally appertains to the region, and raises the barometer above its mean height. The continuance of a South-wester carries off the heavy air, deposits a much lighter body in its stead, and never fails to sink the barometer below its mean height: hence, in the middle parts of Europe, there is a difference of about two inches and a quarter between the highest and lowest states of the barometer. But supposing it to be only two inches, the difference of pressure still amounts to $\frac{1}{13}$ th part of the whole weight of the atmosphere. Now it is evident from the Peruvian observations, that the greatest fluctuation of the barometer, which is at the level of the sea, doth not exceed 0.226 of an inch, or $\frac{1}{133}$ d part of the whole pressure; and if the change should be no greater at the poles, which I think not improbable, it follows, that the measurement of heights by means of the barometer, in middle latitudes, will be more precarious and uncertain than in the torrid and frigid zones.

Such in general were the first ideas which the comparison of the operations of the barometer with the effects
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of the North-east and South-west wind ^(p) on that instrument, suggested with regard to the different densities of the atmosphere in the different zones of the earth.

But since the experiments on the expansion of moist air have shewn its elasticity to be so much greater than that which is dry, I apprehend, that the simple principle of heat and moisture may suffice to account for all the phenomena. Thus it is universally admitted, that there is a greater degree of humidity and heat in the air, near the earth's surface, than there is in the higher regions of the atmosphere. The elasticity or expansion of the lowermost section ^(q) of every column of air, whether
long

^(p) I have been well informed, that in China the North-west wind raises the barometer most, and is highly electrical; it is at the same time the driest and the coldest; and at Canton, under the Northern tropic, there is frequently ice. On the East-coasts of North America the severity of the North-west wind is universally remarked; and there can scarcely be a doubt, that the inhabitants of California, and other parts on the West-side of that great Continent, will, like those on the West of Europe, feel the strong effects of a North-east wind. The extraordinary dryness and density of the wind from the North pole, seems therefore to be occasioned by its passing over the Continent of Europe and Asia on one side, and that of North America on the other. Those who live on the East and West-coasts of South America, will find the driest and coldest winds come to them respectively from the South-west and South-east. As the winds seem to be colder, drier, and denser, in proportion to the extent of land they pass over from the poles towards the equator, so they appear to be more moist, warm, and light, in proportion to the extent of Ocean they pass over from the equator towards the poles. Hence the humidity, warmth, and lightness, of the Atlantic wind to the inhabitants of Europe.

^(q) Mr. DE LUC seems to have suspected something of this kind towards the

long or short, will consequently be greater than the uppermost section of it; for the heat, by dissolving the moisture, produces a vapour lighter than air, which mixing with its particles, removes them farther from each other, increases the elasticity of the general mass, and diminishes its specific gravity comparatively more than it doth that of the section immediately above it, where there is less heat and less moisture. Hence I infer, that the equation for the air, in any assigned vertical, will gradually diminish as the elevation of the place above the sea increases, and that it will vanish at the top of the atmosphere. This is in some respect confirmed by the experiments on the expansion of rare air; for from them it appears, when the particles are very far removed from each other, by a great diminution of pressure, as is undoubtedly the case in the higher regions of the atmosphere, they lose a great part of their elastic force. Thus the equation, answering to any particular temperature, above or below the zero of the scale, at different heights above the surface, will, I apprehend, be expressed by the ordinates to a curve of the hyperbolic order, whose cur-

end of his 8th chap. *sur les difficultés à vaincre*: and in that which follows, he gives proofs of the lightness of vapours with regard to air, saying, that they point out fire to be their vehicle. He afterwards quotes NEWTON with respect to the lightness of a humid atmosphere compared with one that is dry.

vature may be supposed to change fast near the surface of the earth, and differ insensibly from a straight line at great heights above it.

With regard to the latitudinal equation, the same principle of heat and moisture seems to make it probable, that such will become necessary in operating with the barometer; for it is well known, that there is a great degree of humidity in the air between the tropics; and, on the contrary, that the polar atmospheres are very dry. The heat and moisture being greatest at the equator, there the elasticity or equation will likewise be the greatest at the level of the sea; and the zero of the scale will necessarily descend to a lower point of the thermometer, than that to which it corresponds in middle latitudes. As the elasticity of the air at the level of the sea, or equal heights above it, with the same degree of heat, will always be proportionable to the quantity of moisture dissolved in it, therefore it will gradually diminish from the equator towards the poles; that is to say, the zero of the scale will ascend in the thermometer, coincide with the 32d degree in the middle latitudes, and, in its motion upwards, will give the equation to be applied with the contrary sign in high latitudes. Hence I infer, that every latitude, climate, or zone, will not only have its particular zero, but also its particular curve, whose ordinates will

will always measure the equations applicable in the respective situations. The equatorial curve will probably change the fastest, and the others become gradually flatter, as they approach towards the poles, where the greater, but more uniform, density of the atmosphere may occasion it to differ little from a straight line. I apprehend, however, that even at the pole some small diminution might be found to take place in the equation, was it possible, in that region, to prove it by experiments at a sufficient height above the level of the sea.

The table of the equation, depending on the heat of the air, annexed to this paper, is constructed for middle latitudes. It extends to temperatures from 12° to 92° of FAHRENHEIT; and for situations so greatly elevated above the sea, as to make the mean barometer between the two stations stand no higher than 19 inches. As the equation corresponding to the lower parts of the atmosphere, contained in the right-hand columns, will come more frequently into use than that appertaining to the higher regions, comprehended in those on the left; therefore, in the first, it is given for every half; and in the last only, for every whole inch of descent of quicksilver in the tube.

The equation found in the column of 29 inches, corresponds exactly with the expansion of air resulting from

the manometrical experiments; and the ratio of diminution, in the temperature of 52° , hath been taken from the Peruvian observations, supposing it to decrease uniformly $\frac{2}{1000}$ on each inch, or $\frac{16}{1000}$ on the eight inches between 29 and 31. For the sake of simplicity, as well as from the want of sufficient data for ascertaining the lengths of the ordinates of the curve, the arithmetical hath been preferred to any progressive diminution that might have been adopted, though by this mode the results would have agreed better with some of my own, as well as Mr. DE LUC's observations. In each of the columns the equations for particular temperatures, compared with that for 12° or 92° , are reciprocally proportionable, so that the maximum of the rate always corresponds to the space between 52° and 72° , as indicated by the manometer. It will be observed, that though the equation in the table is only given for every 10° of difference of temperature, yet, by the intermediate rates for single degrees in the columns respectively, and the ratio of diminution for the height of the mean barometer above the sea, expressed in that towards the right-hand, the equation for any particular temperature may be readily obtained. The application of this table makes the third part of the rule, for measuring heights with the barometer. When the mean temperature of the column

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of air is above 32° of FAHRENHEIT's thermometer in the shade, add the equation corresponding to the temperature and height of quicksilver in the mean barometer to the logarithmic altitude; when below 32° , subtract the equation from the logarithmic altitude; the sum in the first case, and difference in the last, gives the real height.

Besides the table of equation for the air, adapted to the measurement of the greatest accessible heights the barometer can possibly be applied to in middle latitudes, I have annexed, for the use of those who may prefer simplicity, and still doubt of the vertical diminution, a thermometrical scale of the equation, suited to English and French measures, with their respective thermometers. It will readily be conceived, that the divisions, expressing the 1000th parts in this scale ^(r), are unequal, since they follow the inverse ratio of the thermometrical compared with the manometrical degrees. Where these last are the greatest, as between 52° and 72° , the divisions expressing the equation are the smallest, because a greater

(r) Any scale of this kind, unless it had been mechanically divided by a mathematical instrument-maker, could not be rendered very exact; and it may be expected, that the imperfections in the original will be augmented in copying by the engraver, notwithstanding the utmost care on his part: wherefore, on the left-hand side of the plate, I have annexed the number of degrees and decimal parts of FAHRENHEIT, below the temperature of $91^{\circ}.88$, corresponding to every 1000th parts of the equation, by which means the unequal scale may, at any time, be divided with sufficient accuracy.

number

number of them correspond to the same thermometrical space. When the height is required in fathoms, the zero of FAHRENHEIT corresponds to -71.72 , and the boiling point to $+412.49$; the sum of the two equations 484.21 is the actual expansion of common air from the heat of 212° . When the French toise is made use of as the measure, the zero of the scale hath been shewn to coincide with $57^{\circ}.18$ of FAHRENHEIT, or $+11^{\circ}\frac{1}{4}$ of REAUMUR. The negative equation $134^{\circ}.72$ answering to $-14^{\circ}\frac{1}{4}$ of REAUMUR, and the positive $349^{\circ}.49$ corresponding to $+80^{\circ}$, or the boiling point, being added together, make again 484.21 .

In order to convey a more distinct idea of the effect which heat produces in the dilatation of different kinds of air, compared with quicksilver, along with the scale for the equation I have placed another, expressing the actual and relative expansions, resulting from the mean of the experiments, for every 20° of difference of temperature. This scale is intended to give a comparative view of the manometrical with the thermometrical spaces, mentioned in the second section.

I shall now close this paper, which hath already greatly exceeded the limits I wished to have been able to prescribe to it, with a few remarks on the error of the rule, perceivable in the tables of computation, and the mea-

tures that should, in my opinion, be taken to bring the theory of the barometer to a still greater degree of perfection, such as I believe it to be really capable of.

By inspection of the tables containing the computations of the British observations, it will be seen, that the error of the rule is in general very small. In the London class it is greatest on Shooter's-hill, making the height five feet too little. In those at Taybridge, one of the observations on Schihallien gives a defective result of $29\frac{1}{2}$ feet; but this is easily accounted for, as it certainly arose from the short time given to the barometer to lose the heat it had acquired in carrying upwards, those destined to observe at the summit arriving there too late, that is to say, towards the expiration of the whole hour which the inferior barometer had been observed in. One of the observations on Carmichael-hill, though a small height, is defective eight feet, which I ascribe to the South-west wind and humidity of the air. From the same cause I would account for the uniform defect in the first part of the Edinburgh observations: in the last part of these, the circumstances having changed, the error hath the contrary sign. In the Linhouse class of observations, the same cause of defect appears on the 1st of December, 1775, and on the 20th of November, and 17th of December, 1776. The only result which I consider

consider as very irregular, and do not pretend to account for, is that for the height of Moel Eilio, a hill situated between Carnarvon and Snowdon: the real altitude 2371 feet, is exceeded by the barometrical result 21 feet, though the circumstances were such as, in other cases, generally make it fall short.

At the bottom of the tables of computations I have occasionally substituted Mr. DE LUC's equation for the air, in calculating one or more of the greatest heights, that the difference between the two methods might become more obvious. Thus the first observation on Schi-hallien is defective $67\frac{1}{2}$ feet; the mean of those on Tinto 29 feet; Moel Eilio 41 feet; and Snowdon 81 feet.

With respect to the results that the rule produces on Mr. DE LUC's heights it will be observed, that it answers very well in the cold observations, which, with his rule, were often defective 60 or 70 feet; but gives too much in those that are hot. If, however, the whole of these hot observations had been included, the apparent error would have been less; for the mean defect was taken at $\frac{96}{1000}$ for the hottest temperature, whereas it sometimes amounts to $\frac{110}{1000}$. On the height of the Dole the rule errs in defect; and on the mean of Mr. DE LA CAILLE's observations, at the Cape of Good Hope, it exceeds the truth. By substituting Mr. DE LUC's equation for the air,

in the computations of the Dole and Table-hill, the respective results are defective 96 and 62.6 feet.

To the British observations a table is annexed, containing the barometrical computations of altitudes not yet determined geometrically. In the chief part of these the inferior barometer stood at Belmont-castle, the seat of the lord privy-seal for Scotland, by whose directions the corresponding observations were made. This table likewise comprehends Mr. BANKS's observations in 1772, for the height of the South-pap of Jura, above Freeport in the island of Isla, and those he made the same year, to obtain the height of Mount Hecla, above Hafniford in Iceland.

Lastly, it is to be observed, that in the application of the table, the equation found in the columns $29\frac{1}{2}$, 30, and $30\frac{1}{2}$, will never come into use, except in the measurement of short columns of air, whose bases stand at, or not much above, the level of the sea⁽¹⁾. In an island, whose

(1) Having been accustomed, from the beginning, to call the station of the inferior barometer the place of observation, and to suppose the mean height of its quicksilver to denote the elevation of the place above the sea, for the sake of simplicity I adapted the formula to the height of quicksilver in that barometer, and made all the computations in the tables accordingly. But it having been suggested to me, first by Sir GEORGE SHUCKBURGH, and afterwards by Mr. DE LUC, that this mode, though the easiest, was not strictly accurate, nor consistent with the principles whereon a vertical diminution of the equation for
the

whose climate is so very variable as that of Britain, settled weather should be chosen as the best time for observations. With any sudden fall of the barometer, in any assigned station below its mean height, it is apprehended that the rule will have a tendency to give defective results; and the contrary should happen when, from the increased weight of the atmosphere, it rises much above the mean height.

From what hath been said in the course of this paper, it will be perceived, that though the error of the rule is in general very small, yet now and then such irregularities do occur as plainly shew, that something still remains to be done, in order to perfect the theory of the barometer.

The existence, or otherwise, of a latitudinal equation being a point of the greatest consequence, should be determined with so much care as to leave no doubt remaining on that head. And as this can only be effected by differences that are extremely obvious, the observations for that purpose should be made at the equator, and as near as possible to the poles^(t). Peru is no doubt the best
situation

the heat of the air was founded, I have since changed it to the mean barometer, or middle of the column of air intercepted between the two stations. In this way all the great heights have been re-computed: the smaller altitudes, not being sensibly affected by the alteration, continue as at first.

(t) Some idea may be formed what altitudes on the surface of the globe are
accessible

situation on the globe for conclusive equatorial observations; but as it would be found very difficult to carry any scheme of that kind into execution, such as may be more easily obtained in our West India islands, which have the highest mountains, would be very satisfactory with respect to the expansion and weight of moist air, at different heights above the surface. At the tops of the mountains in the torrid zone, the observations would always be sufficiently cold; but it would be of use likewise, to have the coldest possible at the level of the sea, under or near one of the tropics, when the Sun was in the other.

With regard to observations in the frigid zones, Spitzbergen seems to be as proper a situation as any; though others may no doubt be found in the Northern parts of the Russian empire: and it is presumed, that the Petersburg academy would direct the experiments to be made.

accessible to man, by considering the height above the sea of the inferior line of perpetual snow. In the middle of the torrid zone it appears, from Mr. BOUGUER's observations, to be elevated 5201 yards, and 4476 about the tropics. In middle latitudes there is everlasting snow on the mountains at the height of 3300 yards. In the latitude of 80° North, Lord MULGRAVE found the inferior line of snow to be only about 400 yards above the sea: whence we may conclude, that the surface of the earth, at the pole itself, is for ever covered with snow.

The Peak of Teneriffe, Ætna, the mountains of Auvergne and Rouffillon, as well as Hecla in Iceland, are all very proper for observations in intermediate latitudes.

Within the island of Great Britain, Ben Nevis seems to be the best mountain for barometrical observations, because of its great height, its vicinity to the sea, and that there is very good ground close to its foot (which is rarely the case in the Highlands) for the measurement of the base that would be made use of in the geometrical operations.

One of the chief causes of error in barometrical computations, I apprehend, proceeds from the mode (though simplicity is in its favour) of estimating the temperature of the column of air from that of its extremities, which must be faulty ^(u) in proportion as the height and difference of temperature are great. Where very accurate conclusions are expected, simultaneous observations, at different times of the day, and different seasons of the year, should be made with several barometers, placed at different heights, each accompanied with a thermometer and manometer. By this method, the progression of temperature, as well as the law of diminution of the equation, from the position of the inferior barometer above the sea (if such diminution doth really take place)

(u) This is taken notice of by Mr. DE LUC.

would

would be obtained with certainty. Supposing, for instance, Ben Nevis was divided into four sections, five barometers, with as many observers, would be necessary. This number may seem great, but the expence of people employed in that way would be inconsiderable. And if it should be judged proper, there could not surely be any great difficulty in providing reasonable accommodation for an observer, who should live a whole year at the top of the mountain, while another made corresponding observations below.

But the perfecting of the theory of the barometer is not the only advantage that would accrue from a combination of these observations; for, while they were carrying on in different climates, or zones of the earth, good opportunities would offer of determining the refractions, as well as the force of gravity and figure of the globe, from the vibrations of the pendulum.

The mean expansion of common air is already found to be greater than what was formerly supposed; wherefore the mean refraction will be altered proportionably. And since the expansion of moist air is found to be so much greater than that of common air, a larger field for inquiry and investigation is now laid open.

With respect to the experiments with the pendulum, Mr. BOUGUER seems to have been the only person, so far

as I know, who hath taken the density of the medium in which it performed its vibrations into the account, and given us its length at the equator in vacuo. But if we are to judge of the density of the air in the frigid zone from the barometrical observations at Spitzbergen, the pendulum there must have lost so much of its weight, as to have lessened considerably the number of vibrations below what they would have been in vacuo, in the same temperature. Having considered the effect that this would produce, I collected the best experiments that have hitherto been made with the pendulum into one view, and having applied the equation that the density of the air, in which they severally vibrated, seemed to require; I found from computation, that the ratio of the diameters of the earth is (as Mr. BOUGUER supposed it) nearly that of 178 to 179, instead of 229 to 230, as estimated by Sir ISAAC NEWTON, and which agrees very nearly with the mean result from the measurement of the degrees of the meridian. The experiments with the pendulum are so simple and easy, may be repeated so often in all situations, and are so much more consistent with each other, than the measured lengths of degrees of latitude, that it appears to be incomparably the best method for determining the figure of the earth. And if it should really be found so flat a spheroid as the pendu-

lum seems to make it, both parallaxes and refractions, will require correction.

Upon the whole, though I wished to be concise in the recital of the experiments and observations contained in this paper, yet I found it necessary at the same time to be explicit. Some of them were either entirely new, or managed in a different manner from what they had formerly been. This forced me into a comparison of many minute circumstances attending the operations, and to a tedious, though necessary, combination of the various results. Without taking a comprehensive view of the whole matter, and stating every thing with fairness and candour, I could not convey to others the ideas I entertained of it myself; nor enable them to judge, how far I had been just in the conclusions already drawn, or consistent in my suppositions concerning such points as are yet left doubtful. If I have been obliged to differ from Mr. DE LUC, it is because the British observations, as well as his own (considered by their extremes) seem to authorize it: he is himself too candid to suppose, that I have had criticism in view, or indeed any other object, than that of contributing my mite towards the discovery of the truth, from the very good foundation which he hath already laid for it. I am aware it may be alledged, that I have rendered the theory of measuring heights by

the barometer so much more complicate and difficult, as perhaps to deter others from applying it to useful purposes. To this I answer, that though it seem utterly impossible to render what is really intricate in its nature, extremely simple; yet that the best and surest method of arriving at simplicity at last will, in the first place, be to ascertain the limits of deviation of the rule, by a proper number of good observations, made in circumstances and situations as different as possible from each other. In the present state of the matter, I doubt not but the barometer will be found to give results sufficiently near the truth for all ordinary purposes, the nicer business of levelling alone excepted. It is the only instrument by which the relative heights of places, in very great and distant tracts of country, can easily and speedily be obtained, by the pressure of the atmosphere alone. The method of using it is attainable by all, requiring only a little habit, and some degree of attention to prevent the admission of air into the tube. Few people are qualified for the tedious and very laborious operations of accurate geometrical measurements. Mountainous countries rarely afford bases of sufficient length, which, to avoid error, must be measured again and again with the utmost care. Instruments of the most expensive kinds must be employed to take the angles; at the same time that a thorough knowledge of their use,

and a scrupulous attention to their various adjustments, become indispensably necessary. In short, the facility of one method, compared with the other, is so exceedingly obvious as to need nothing else to recommend it as a subject very curious and useful, and therefore well worthy of the researches of philosophers, till, by their united labours, it hath been brought to perfection.

Table shewing the equation depending on the temperature of the column of air.

Mean temperature of the column of air.	Mean equated height of quicksilver in the inferior and superior column.												
	Inches 19		20	21	22		23	24	25		26		27
92°	Add to the logarithmic altitude.	89.364	—	95.456	101.548	107.640	—	113.733	119.825	125.918	—	132.010	—
82		74.967	1.44	80.078	85.189	90.300	1.73	95.411	100.522	105.633	2.03	110.744	2.13
72		60.028	1.49	64.120	68.213	72.305	1.80	76.398	80.491	84.583	2.10	88.675	2.21
62		44.818	1.52	47.873	50.928	53.983	1.83	57.039	60.094	63.150	2.14	66.205	2.25
52		29.335	1.55	31.335	33.335	35.355	1.87	37.335	39.335	41.335	2.18	43.335	2.29
42		14.394	1.49	15.376	16.358	17.340	1.80	18.321	19.303	20.284	2.10	21.266	2.21
			1.44				1.73				2.03		2.13
32	When the mean temperature of the column of air to be reduced is 32°.												
22	Subtract from the log. altitude.	13.852	1.39	14.796	15.741	16.685	1.67	17.630	18.575	19.519	1.95	20.463	2.05
12		27.162	1.33	29.014	30.866	32.718	1.60	34.569	36.421	38.273	1.88	40.125	1.97

the temperature of the column of air, and its elevation above the sea, as denoted
inferior and superior barometers.

height of quicksilver in the inferior and superior barometers. Equation in thousandth parts of the logarithmic altitude.

24	25		26		26½		27		27½		28		28½		29
119.825	125.918	— 2.03	132.010	— 2.13	135.057	— 2.18	138.103	— 2.22	141.149	— 2.27	144.195	— 2.32	147.242	— 2.37	150.288
100.522	105.633	— 2.10	110.744	— 2.21	113.299	— 2.26	115.855	— 2.31	118.411	— 2.36	120.966	— 2.41	123.522	— 2.46	126.077
80.491	84.583	— 2.14	88.675	— 2.25	90.722	— 2.30	92.768	— 2.35	94.814	— 2.40	96.860	— 2.45	98.907	— 2.51	100.953
60.094	63.150	— 2.18	66.205	— 2.29	67.733	— 2.34	69.261	— 2.39	70.789	— 2.45	72.316	— 2.50	73.844	— 2.55	75.372
39.335	41.335	— 2.10	43.335	— 2.21	44.335	— 2.26	45.335	— 2.31	46.335	— 2.36	47.335	— 2.41	48.335	— 2.46	49.335
19.303	20.284	— 2.03	21.266	— 2.13	21.757	— 2.18	22.248	— 2.22	22.739	— 2.27	23.229	— 2.32	23.720	— 2.37	24.211

mean temperature of the column of air to be measured is at 32°, the differences of the logarithms give the real height in

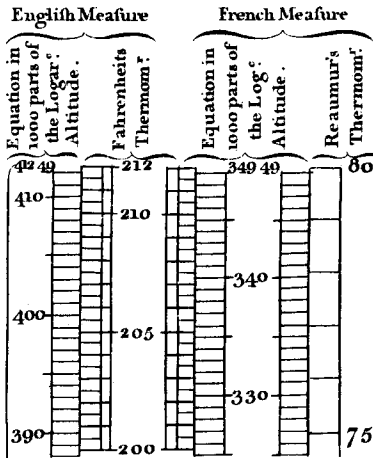
18.575	19.519	1.95 — 1.88	20.463	2.05 — 1.97	20.936	2.09 — 2.01	21.408	2.14 — 2.06	21.880	2.19 — 2.10	22.353	2.24 — 2.15	22.825	2.28 — 2.19	23.297
36.421	38.273	—	40.125	—	41.051	—	41.976	—	42.902	—	43.828	—	44.754	—	45.680

thousandth parts of the logarithmic altitude.

s of the logarithms give the real height in fathoms and 1000th parts.

19	22.353	$\frac{2.24}{-}$	22.825	$\frac{2.28}{-}$	23.297	$\frac{2.33}{-}$	23 769	$\frac{2.38}{-}$	24.242	$\frac{2.42}{-}$	24.714	$\frac{2.47}{-}$	$\left\{ \begin{array}{l} 0.47225 \\ 0.94450 \\ 0.925875 \\ 1.85175 \end{array} \right.$	Subtract from the log. altitude.	
10		$\frac{2.15}{-}$		$\frac{2.19}{-}$		$\frac{2.24}{-}$		$\frac{2.28}{-}$		$\frac{2.33}{-}$		$\frac{2.37}{-}$			
—	43.828	$\frac{+}{-}$	44.754	$\frac{-}{-}$	45.680	$\frac{-}{-}$	46.606	$\frac{-}{-}$	47.532	$\frac{-}{-}$	48.458	$\frac{-}{-}$			

SCALE for the Equation of the Air.



By means of these numbers expressing the Degrees of Fahr. below 92.88 answering to every 1000 parts of the Equation for the Air, the unequal Scale may be divided.

92.88.

4.15

87.73.

4.10

83.63.

4.06

79.57.

4.02

75.55.

3.97

71.38.

3.93

67.65.

3.87

63.78.

3.84

59.94

3.82

56.12.

3.88

52.24.

3.94

48.30

3.99

44.31.

4.05

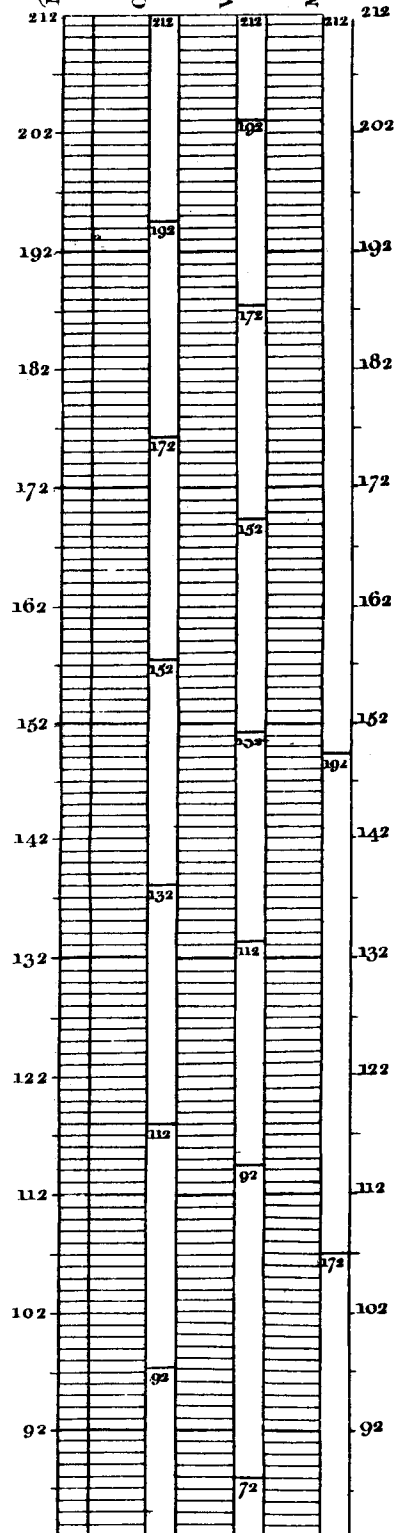
Add to the Logarithmic Altitude.

Add to the Logarithmic Altitude.

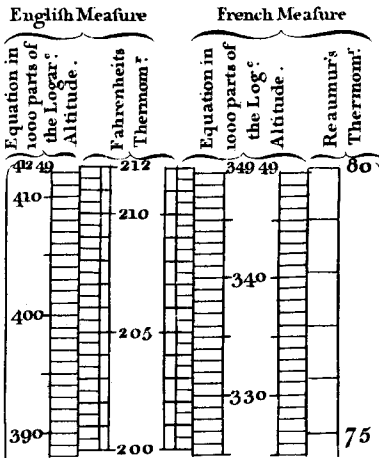
A SCALE expressing the Expansion of different kinds of Air with regard to Mercury affected by 212° of Fahrenheit.

Actual Expansion of 1000 equal parts.

Mercury. 17.06
Common Air. 484.21
Very Rare Air. 166.66
Moist Air. 2038.06



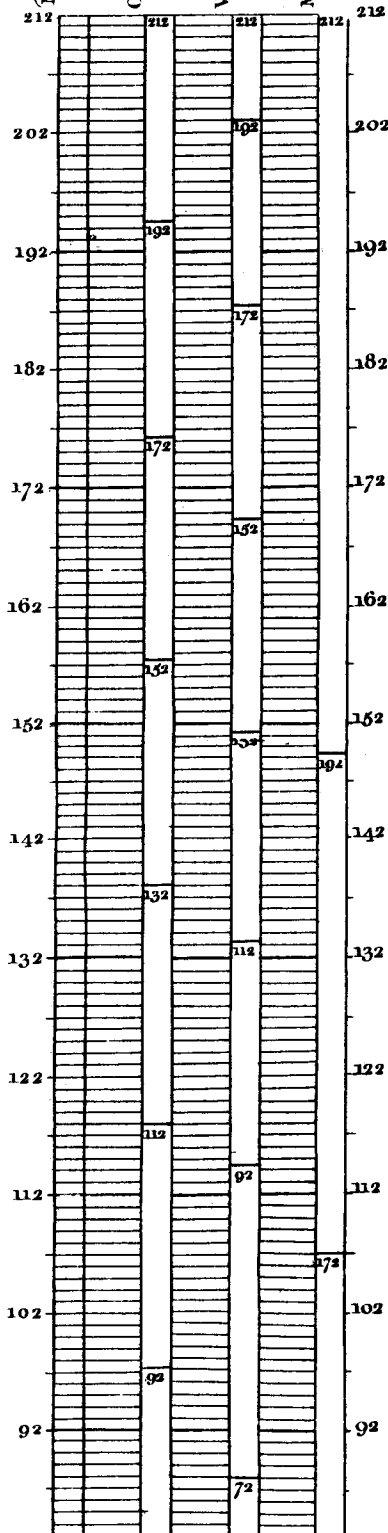
SCALE for the Equation of the Air.



A SCALE expressing the Expansion of different kinds of Air with regard to Mercury affected by 212° of Fahrenheit.

Actual Expansion of 1000 equal parts.

Mercury.	Common Air.	Very Rare Air.	Moist Air.
17.06	484.21	166.66	2038.06



(the unequal Scale may be divided.

8.

5

3.

0

3.

3.

7.

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5.

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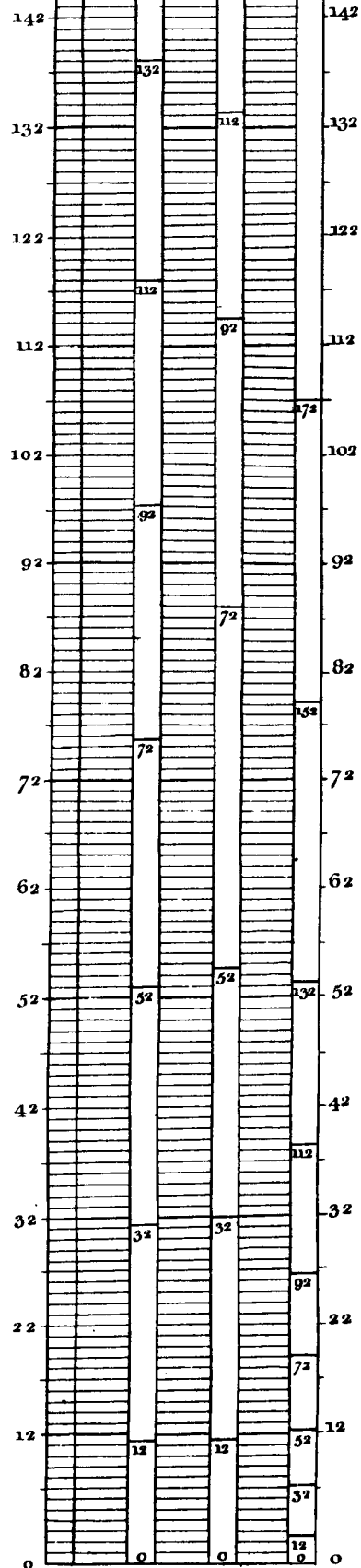
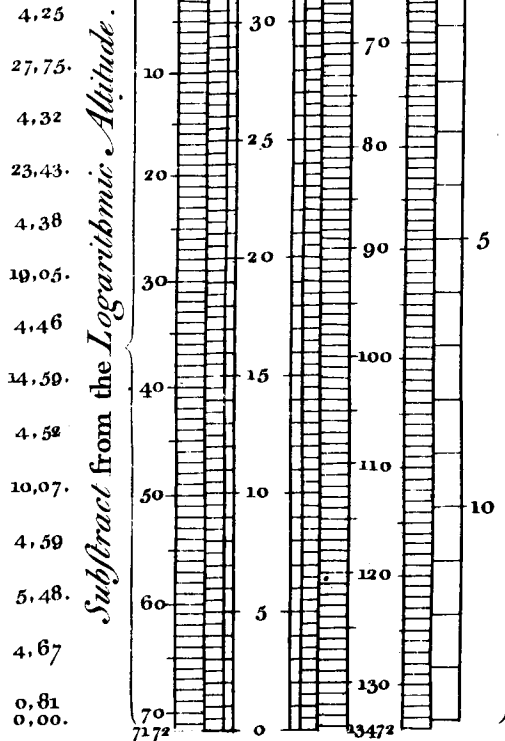
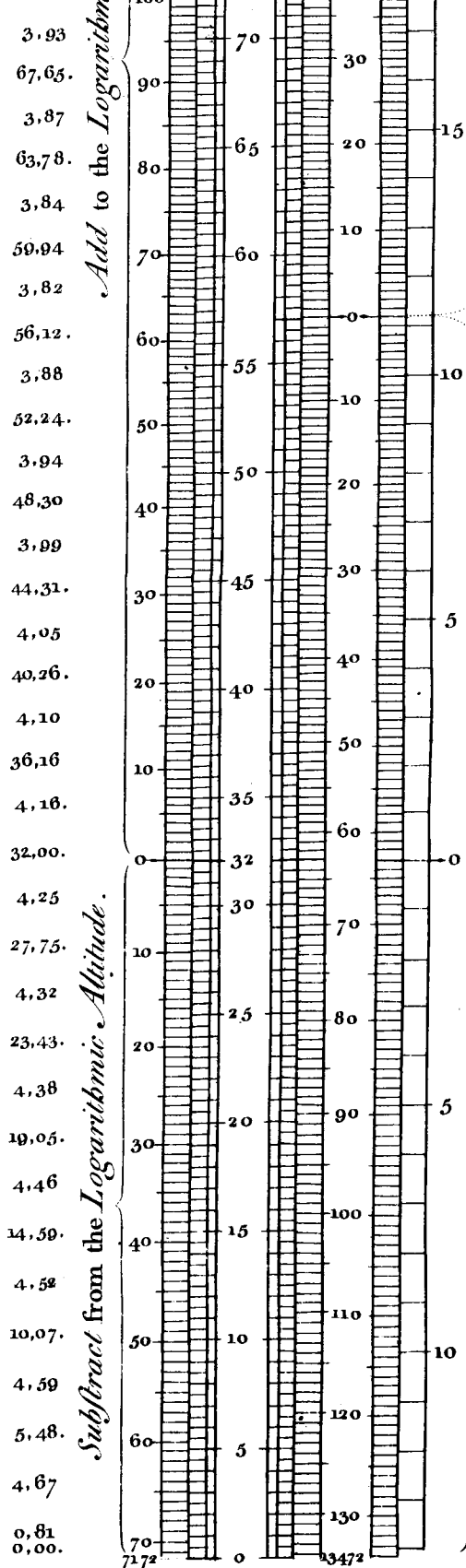
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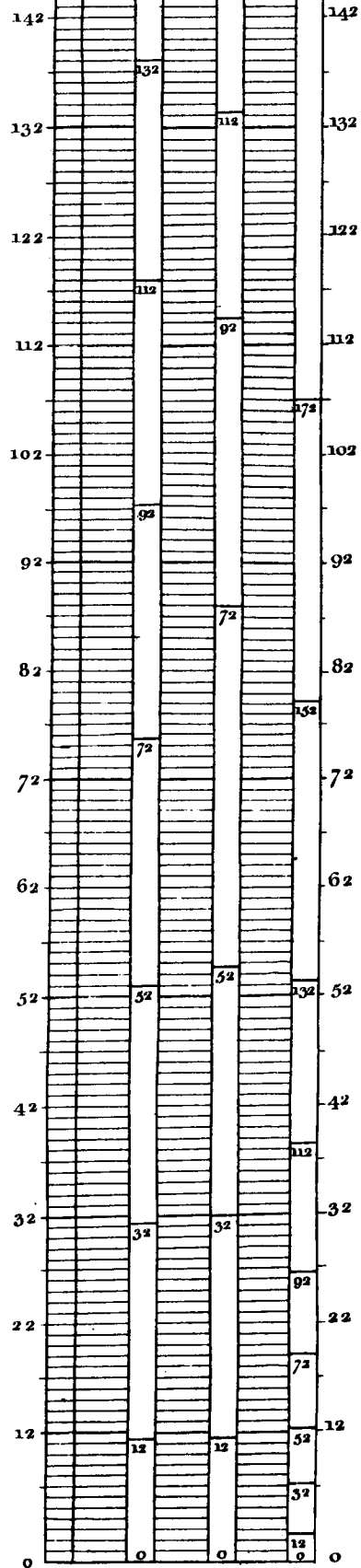
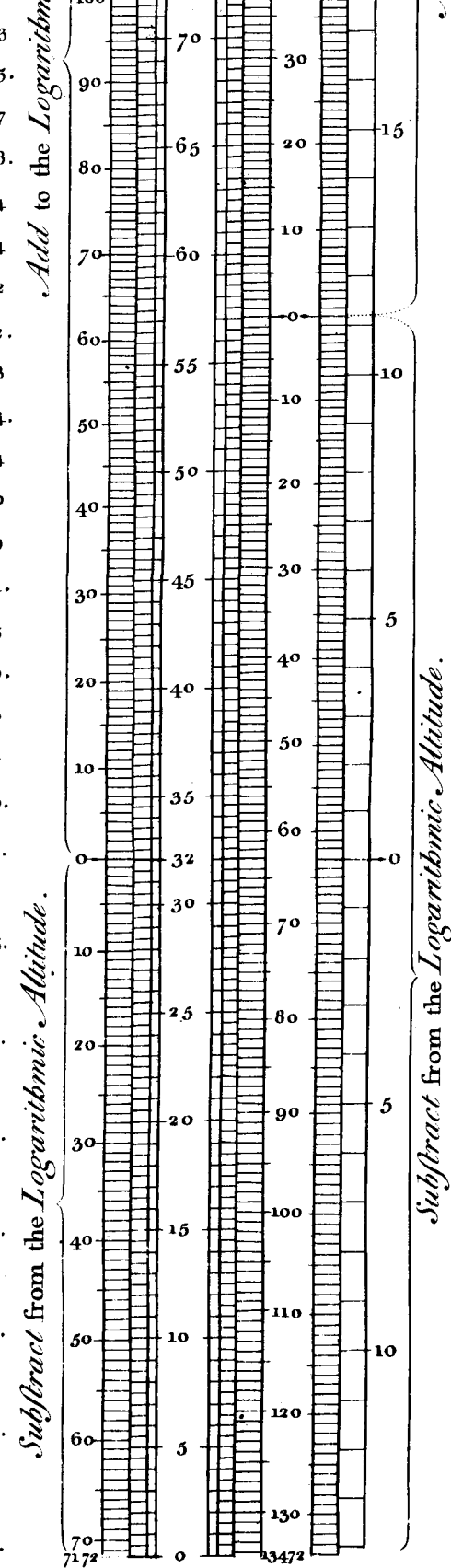
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Add to the Logarithmic Altitude.

Add to the Logarithmic Altitude.





N° I. Computations of barometrical observations made on heights

Geometrical heights of the stations in feet.	Date of the observations, winds, &c.	Observed heights of the inferior and superior barometers.	Temperature of the quicksilver.	Equation for the heat of the quick-silver.	Equated heights of the barometers.	Logarithmic result in feet.	Logar. excess or defect in ft. and also in 1000th parts.	Temperature of the air	
								Particular.	Mean.
St. Paul's Church-yard North-side, and iron-gallery over the dome, 281 feet.	1774, Dec. 1. 9 ^h 27' wind N.W. }	29.659 29.338	33 ³ / ₄ 34	—006 —006	29.653 29.332	283.6	{ +2.6ft. = $\frac{2}{1000}$	32 ³ / ₄ 33 ³ / ₄	33 ³ / ₄
	Dec. 31. 11 ^h 52' A.M. wind N.E. }	30.187 29.864	35 ¹ / ₂ 34 ³ / ₄	—011 —009	30.176 29.855	279.5	{ — 1.5 = 5.5	33 34	33 ¹ / ₂
	April 22. 11 ^h 55' A.M. E. wind. }	30.136 29.839	50 ¹ / ₄ 53	—060 —069	30.076 29.770	266.5	{ —14.5 = 54.4	49 53	51
Top of Paul's-stairs, and the said gallery, 324 feet.	1774, Ap. 22. 0 ^h 50' P.M. }	30.206 29.842	55 ³ / ₄ 53 ³ / ₄	—080 —071	30.126 29.771	308.9	{ —15.1 = 49.	55 ¹ / ₄ 53 ³ / ₄	54 ¹ / ₂
	Dec. 1. 10 ^h 2' A.M. }	29.717 29.344	37 35	—016 —009	29.701 29.335	323.1	{ — 0.9 = 3.	37 ¹ / ₄ 34	35 ³ / ₄
	Dec. 31. 0 ^h 22' P.M. }	30.230 29.858	35 ¹ / ₂ 34 ³ / ₄	—011 —009	30.219 29.849	321.	{ — 3. = 9.3	34 ³ / ₄ 34 ¹ / ₄	34 ¹ / ₂
Scotland-yard wharf, and Old Spaniard dining-room, 422 feet.	1774, Dec. 24. 10 ^h 7' A.M. N.E. wind. }	30.844 30.349	33 ¹ / ₂ 33 ¹ / ₄	—005 —004	30.839 30.345	420.8	{ — 1.2 = 3.5	34 ¹ / ₄ 33 ¹ / ₄	33 ³ / ₄
	1774, Nov. 28. 9 ^h 48' A.M. }	29.684 29.287	35 ¹ / ₂ 34 ³ / ₄	—011 —009	29.673 29.278	349.2	{ — 2.8 = 8.5	35 ³ / ₄ 34 ³ / ₄	35
	Dec. 9. 0 ^h 15' P.M. N.W. wind, fnow. }	29.647 29.234	27 ¹ / ₂ 25 ¹ / ₄	+015 +022	29.662 29.256	359.	{ + 7. = 19.7	27 ¹ / ₂ 23 ¹ / ₄	25 ¹ / ₂
Great Pulteney-street, and the said dining-room, 352 feet.	Dec. 24. 10 ^h 52' A.M. N.E. wind. }	30.758 30.343	35 33	—010 —003	30.748 30.340	348.1	{ — 3.9 = 11.2	34 ¹ / ₂ 30 ³ / ₄	32 ¹ / ₂
	1775, June 13. 11 ^h 7' A.M. S.W. wind. }	30.044 29.674	69 69	—121 —117	29.923 29.557	320.7	{ —31.3 = 97.6	67 ¹ / ₂ 72 ¹ / ₂	70
	1776, May 10. 10 ^h 30' A.M. }	30.096 29.706	53 51 ¹ / ₄	—069 —063	30.027 29.643	335.4	{ —16.6 = 50.	51 ¹ / ₂ 49 ³ / ₄	50 ¹ / ₂
	May 30. 11 ^h 40' A.M. S.W. wind. }	29.900 29.521	66 63	—111 —100	29.789 29.421	323.9	{ —28.1 = 86.7	66 63	64
	June 20. 0 ^h 15' P.M. }	30.268 29.898	71 ¹ / ₂ 71 ¹ / ₂	—129 —127	30.139 29.771	320.1	{ —31.9 = 99.7	71 71 ¹ / ₂	71
	July 16. 0 ^h 15' P.M. }	29.625 29.253	67 ¹ / ₂ 67 ¹ / ₂	—113 —112	29.512 29.141	329.6	{ —22.4 = 68.	67 ³ / ₄ 65 ¹ / ₂	66
	Aug. 26. 10 ^h 35' A.M. }	30.132 29.738	59 ¹ / ₂ 57 ¹ / ₄	—092 —082	30.040 29.656	335.2	{ —16.8 = 50.1	59 ¹ / ₂ 56 ¹ / ₂	57
	Aug. 27. 11 ^h 45' A.M. }	30.020 29.631	62 ¹ / ₄ 60	—099 —091	29.921 29.540	334.	{ —18. = 54.	62 58 ¹ / ₄	60

barometrical observations made on heights in and near London.

	Temperature of the quicksilver.	Equation for the heat of the quicksilver.	Equated heights of the barometers.	Logarithmic result in feet.	Logar. excess or defect in ft. and also in 1000th parts.	Temperature of the air,		Equation by the rule in 1000th parts, and also in feet.	Result by the rule,		Error of the rule in feet.	Ratio of the weight of quicksilver to air, being 1.
						Particular.	Mean.		Particular.	Mean.		
59 338	33 ^{0.3} / ₄ 34	—006 —006	29.653 29.332	} 283.6	{ +2.6ft. = ⁹ / ₁₀₀₀	32 ^{0.3} / ₄ 33 ^{0.3} / ₄	33 ^{0.1} / ₄	{ + ^{3.8} / ₁₀₀₀ = 1. ft. }	284.6			
187 864	35 ¹ / ₂ 34 ³ / ₄	—011 —009	30.176 29.855	} 279.5	{ — 1.5 = 5.5	33 34	33 ¹ / ₂	{ + 4. = 1. }	280.5	— — 281.4	— — +0.4	10505
136 839	50 ¹ / ₄ 53	—060 —069	30.076 29.770	} 266.5	{ —14.5 = 54.4	49 53	51	{ +47.5 = 12.7 }	279.2	— —	— —	11056
206 842	55 ³ / ₄ 53 ³ / ₄	—080 —071	30.126 29.771	} 308.9	{ —15.1 = 49.	55 ¹ / ₄ 53 ³ / ₄	54 ¹ / ₂	{ +55. = 17. }	325.9	— —	— —	10860
717 344	37 35	—016 —009	29.701 29.335	} 323.1	{ — 0.9 = 3.	37 ¹ / ₄ 34	35 ³ / ₄	{ + 6.3 = 2. }	325.1	— — 324.6	— — +0.6	
230 858	35 ¹ / ₂ 34 ³ / ₄	—011 —009	30.219 29.849	} 321.	{ — 3. = 9.3	34 ³ / ₄ 34 ¹ / ₄	34 ¹ / ₂	{ + 5.8 = 1.0 }	322.8	— —	— —	10565
844 349	33 ¹ / ₂ 33 ¹ / ₄	—005 —004	30.839 30.345	} 420.8	{ — 1.2 = 3.5	34 ¹ / ₄ 33 ¹ / ₄	33 ³ / ₄	{ + 4. = 0.9 }	421.7	— —	—0.5	10251
684 287	35 ¹ / ₂ 34 ³ / ₄	—011 —009	29.673 29.278	} 349.2	{ — 2.8 = 8.5	35 ³ / ₄ 34 ³ / ₄	35	{ + 7. = 2.4 }	351.6	— —	— —	10694
647 234	27 ¹ / ₂ 25 ¹ / ₄	+015 +022	29.662 29.256	} 359.	{ + 7. = 19.7	27 ¹ / ₂ 23 ¹ / ₄	25 ¹ / ₂	{ —14.5 = 5.2 }	353.8	— —	— —	10404
758 343	35 33	—010 —003	30.748 30.340	} 348.1	{ — 3.9 = 11.2	34 ¹ / ₂ 30 ¹ / ₄	32 ⁵ / ₈	{ + 1.2 = 0.4 }	348.5	— —	— —	10328
044 674	69 69	—121 —117	29.923 29.557	} 320.7	{ —31.3 = 97.6	67 ¹ / ₂ 72 ¹ / ₂	70	{ +96. = 30.8 }	351.5	— —	— —	11416
096 706	53 51 ¹ / ₄	—069 —063	30.027 29.643	} 335.4	{ —16.6 = 50.	51 ¹ / ₂ 49 ³ / ₄	50 ³ / ₄	{ +46.9 = 15.7 }	351.1	— —	— —	10971
900 521	66 63	—111 —100	29.789 29.421	} 323.9	{ —28.1 = 86.7	66 63	64 ¹ / ₂	{ +81.8 = 26.5 }	350.4	— — 353.5	— — +1.5	11447
268 898	71 ¹ / ₂ 71 ¹ / ₂	—129 —127	30.139 29.771	} 320.1	{ —31.9 = 99.7	71 71 ¹ / ₂	71 ¹ / ₄	{ +101. = 32.3 }	352.4	— —	— —	11416
625 253	67 ¹ / ₂ 67 ¹ / ₂	—113 —112	29.512 29.141	} 329.6	{ —22.4 = 68.	67 ³ / ₄ 65 ¹ / ₂	66 ³ / ₄	{ +87.4 = 28.8 }	358.4	— —	— —	11355
132 738	59 ¹ / ₂ 57 ¹ / ₄	—092 —082	30.040 29.656	} 335.2	{ —16.8 = 50.1	59 ¹ / ₂ 56 ¹ / ₂	57 ³ / ₄	{ +65. = 21.8 }	357.0	— —	— —	10887
020 631	62 ¹ / ₄ 60	—099 —091	29.921 29.540	} 334.	{ —18. = 54.	62 58 ¹ / ₄	60	{ +70.2 = 23.4 }	357.4	— —	— —	11028

over the dome, 281 feet.	April 22. 11 ^h 55' } A.M. E. wind. }	29.804 29.839	34 ³ / ₄ —009 53—069	29.855 29.770	266.5	{ —14.5 =54.4	49 53	51
	1774, Ap. 22. 0 ^h 50' } P.M. }	30.206 29.842	55 ³ / ₄ —080 53 ³ / ₄ —071	30.126 29.771	308.9	{ —15.1 =49.	55 ¹ / ₄ 53 ³ / ₄	54 ¹ / ₂
Top of Paul's-stairs, and the laid gal- lery, 324 feet.	Dec. 1. 10 ^h 2' A.M. } Dec. 31. 0 ^h 22' P.M. }	29.717 29.344	37—016 35—009	29.701 29.335	323.1	{ — 0.9 = 3.	37 ¹ / ₄ 34	35 ³ / ₄
	1774, Dec. 24. 10 ^h 7' } A.M. N.E. wind. }	30.844 30.349	33 ¹ / ₂ —005 33 ¹ / ₄ —004	30.839 30.345	420.8	{ — 1.2 = 3.5	34 ¹ / ₄ 33 ³ / ₄	33 ³ / ₄
Scotland-yard wharf, and Old Spaniard dining-room, 422 feet.	1774, Nov. 28. 9 ^h } 48' A.M. }	29.684 29.287	35 ¹ / ₂ —011 34 ³ / ₄ —009	29.673 29.278	349.2	{ — 2.8 = 8.5	35 ³ / ₄ 34 ¹ / ₄	35
	Dec. 9. 0 ^h 15' P.M. } N.W. wind, fnow. }	29.647 29.234	27 ¹ / ₂ +015 25 ¹ / ₄ +022	29.662 29.256	359.	{ + 7. =19.7	27 ¹ / ₂ 23 ³ / ₄	25 ¹ / ₂
	Dec. 24. 10 ^h 52' } A.M. N.E. wind. }	30.758 30.343	35—010 33—003	30.748 30.340	348.1	{ — 3.9 =11.2	34 ¹ / ₂ 30 ³ / ₄	32 ¹ / ₂
	1775, June 13. 11 ^h } 7' A.M. S.W. wind. }	30.044 29.674	69—121 69—117	29.923 29.557	320.7	{ —31.3 =97.6	67 ¹ / ₂ 72 ¹ / ₂	70
	1776, May 10. 10 ^h } 30' A.M. }	30.096 29.706	53—069 51 ¹ / ₄ —063	30.027 29.643	335.4	{ —16.6 =50.	51 ¹ / ₂ 49 ³ / ₄	50 ¹ / ₂
Great Pulteney- street, and the laid dining-room, 352 feet.	May 30. 11 ^h 40' } A.M. S.W. wind. }	29.900 29.521	66—111 63—100	29.789 29.421	323.9	{ —28.1 =86.7	66 63	64
	June 20. 0 ^h 15' P.M. }	30.268 29.898	71 ¹ / ₂ —129 71 ¹ / ₂ —127	30.139 29.771	320.1	{ —31.9 =99.7	71 71 ¹ / ₂	71
	July 16. 0 ^h 15' P.M. }	29.625 29.253	67 ¹ / ₂ —113 67 ¹ / ₂ —112	29.512 29.141	329.6	{ —22.4 =68.	67 ³ / ₄ 65 ¹ / ₂	66
	Aug. 26. 10 ^h 35' } A.M. }	30.132 29.738	59 ¹ / ₂ —092 57 ¹ / ₄ —082	30.040 29.656	335.2	{ —16.8 =50.1	59 ¹ / ₂ 56 ¹ / ₂	57
	Aug. 27. 11 ^h 45' } A.M. }	30.020 29.631	62 ¹ / ₄ —099 60—091	29.921 29.540	334.	{ —18. =54.	62 58 ¹ / ₄	60
	Sept. 2. 10 ^h 15' } AM. }	29.294 28.918	60—089 58 ¹ / ₂ —084	29.205 28.834	333.1	{ —18.9 =56.8	59 ¹ / ₂ 59 ¹ / ₂	59
Pagoda in Kew-gar- dens, 116.5 feet.	1773, Dec. 20. 1 ^h } 22' P.M. mean of 6 observations with 3 barometers. }	29.351 29.226	49 ¹ / ₄ —052 49 ¹ / ₄ —052	29.299 29.174	111.4	{ — 5.1 =45.8	49 ¹ / ₄ 49 ¹ / ₄	49
	1774. Apr. 27. 4 ^h } P.M. mean of 4 obl. }	29.762 29.282	57 ¹ / ₄ —082 56 ¹ / ₂ —077	29.680 29.205	420.4	{ —23.6 =56.1	52 ¹ / ₂ 58 ¹ / ₂	55
Gun-wharf of Woolwich-warren, and upper story of Shooter's-hill inn, 444 feet.	Apr. 27. 6 ^h 30' P.M. } mean of 2 obl. }	29.773 29.302	54—072 55 ¹ / ₄ —074	29.701 29.228	418.3	{ —25.7 =61.4	49 49 ¹ / ₂	49
	Apr. 28. 5 ^h A.M. } mean of 5 obl. }	29.805 29.336	44 ¹ / ₂ —041 48 ³ / ₄ —053	29.764 29.283	424.5	{ —19.5 =46.	43 41 ¹ / ₄	42

136 839	50 $\frac{1}{4}$ 53	-060 -069	30.076 29.770	} 266.5	{ -14.5 =54.4	49 53	} 51	{ +47.5 =12.7	279.2	-	-	-	-	11056
206 842	55 $\frac{3}{4}$ 53 $\frac{3}{4}$	-080 -071	30.126 29.771	} 308.9	{ -15.1 =49.	55 $\frac{1}{4}$ 53 $\frac{3}{4}$	} 54 $\frac{1}{2}$	{ +55. =17.	325.9	-	-	-	-	10860
717 344	37 35	-016 -009	29.701 29.335	} 323.1	{ -0.9 =3.	37 $\frac{1}{4}$ 34	} 35 $\frac{3}{4}$	{ +6.3 =2.	325.1	} 324.6	+0.6	-	-	10565
230 858	35 $\frac{1}{2}$ 34 $\frac{3}{4}$	-011 -009	30.219 29.849	} 321.	{ -3. =9.3	34 $\frac{3}{4}$ 34 $\frac{1}{4}$	} 34 $\frac{1}{2}$	{ +5.8 =1.0	322.8					
844 349	33 $\frac{1}{2}$ 33 $\frac{1}{4}$	-005 -004	30.839 30.345	} 420.8	{ -1.2 =3.5	34 $\frac{1}{4}$ 33 $\frac{3}{4}$	} 33 $\frac{3}{4}$	{ +4. =0.9	421.7					
684 287	55 $\frac{1}{2}$ 34 $\frac{3}{4}$	-011 -009	29.673 29.278	} 349.2	{ -2.8 =8.5	35 $\frac{3}{4}$ 34 $\frac{1}{4}$	} 35	{ +7. =2.4	351.6	-	-	-	-	10694
647 234	27 $\frac{1}{2}$ 25 $\frac{1}{4}$	+015 +022	29.662 29.256	} 359.	{ +7. =19.7	27 $\frac{1}{2}$ 23 $\frac{3}{4}$	} 25 $\frac{1}{2}$	{ -14.5 =5.2	353.8	-	-	-	-	10404
758 343	35 33	-010 -003	30.748 30.340	} 348.1	{ -3.9 =11.2	34 $\frac{1}{2}$ 30 $\frac{3}{4}$	} 32 $\frac{5}{8}$	{ +1.2 =0.4	348.5	-	-	-	-	10328
044 674	69 69	-121 -117	29.923 29.557	} 320.7	{ -31.3 =97.6	67 $\frac{1}{2}$ 72 $\frac{1}{2}$	} 70	{ +96. =30.8	351.5	-	-	-	-	11416
096 706	53 51 $\frac{1}{4}$	-069 -063	30.027 29.643	} 335.4	{ -16.6 =50.	51 $\frac{1}{2}$ 49 $\frac{3}{4}$	} 50 $\frac{3}{4}$	{ +46.9 =15.7	351.1	-	-	-	-	10971
900 521	66 63	-111 -100	29.789 29.421	} 323.9	{ -28.1 =86.7	66 63	} 64 $\frac{1}{2}$	{ +81.8 =26.5	350.4	} 353.5	+1.5	-	-	11447
268 898	71 $\frac{1}{2}$ 71 $\frac{1}{2}$	-129 -127	30.139 29.771	} 320.1	{ -31.9 =99.7	71 71 $\frac{1}{2}$	} 71 $\frac{1}{4}$	{ +101. =32.3	352.4					
625 253	67 $\frac{1}{2}$ 67 $\frac{1}{2}$	-113 -112	29.512 29.141	} 329.6	{ -22.4 =68.	67 $\frac{3}{4}$ 65 $\frac{1}{2}$	} 66 $\frac{3}{4}$	{ +87.4 =28.8	358.4					
1132 738	59 $\frac{1}{2}$ 57 $\frac{1}{4}$	-092 -082	30.040 29.656	} 335.2	{ -16.8 =50.1	59 $\frac{1}{2}$ 56 $\frac{1}{2}$	} 57 $\frac{3}{4}$	{ +65. =21.8	357.0	-	-	-	-	10887
020 631	62 $\frac{1}{4}$ 60	-099 -091	29.921 29.540	} 334.	{ -18. =54.	62 58 $\frac{1}{4}$	} 60	{ +70.2 =23.4	357.4	-	-	-	-	11028
1294 918	60 58 $\frac{1}{2}$	-089 -084	29.205 28.834	} 333.1	{ -18.9 =56.8	59 $\frac{1}{2}$ 59 $\frac{1}{2}$	} 59 $\frac{1}{2}$	{ +69. =23.	356.1	-	-	-	-	11355
1351 1226	49 $\frac{1}{4}$ 49 $\frac{1}{4}$	-052 -052	29.299 29.174	} 111.4	{ -5.1 =45.8	49 $\frac{1}{4}$ 49 $\frac{1}{4}$	} 49 $\frac{1}{4}$	{ +43.3 =4.8	116.2	-	-	-0.3	-	11184
1762 1282	57 $\frac{1}{4}$ 56 $\frac{1}{2}$	-082 -077	29.680 29.205	} 420.4	{ -23.6 =56.1	52 $\frac{1}{2}$ 58 $\frac{1}{2}$	} 55 $\frac{1}{2}$	{ +59.2 =24.9	445.3	-	-	-	-	11170
1773 1302	54 55 $\frac{1}{4}$	-072 -074	29.701 29.228	} 418.3	{ -25.7 =61.4	49 49 $\frac{1}{2}$	} 49 $\frac{1}{4}$	{ +43.5 =18.2	436.5	} 438.9	-5.1	-	-	11217
1805 1336	44 $\frac{1}{2}$ 48 $\frac{1}{4}$	-041 -053	29.764 29.283	} 424.5	{ -19.5 =46.	43 41 $\frac{1}{4}$	} 42 $\frac{1}{8}$	{ +24.5 =16.4	434.9					

N^o II. Computations of barometrical observations made on heights
and N^o III. of those near Lanark.

N ^o II. near Taybridge.									
Geometrical heights of the stations in feet.	Date of the observa- tions, winds, &c.	Observed heights of the inferior and superior ba- rometers.	Temperature of the quicksilver.	Equation for the heat of the quick- silver.	Equated heights of the barome- ters.	Logarithmic result in feet.	Logar. excess or defect in ft. and also in 1000th parts.	Temperature of the air,	
								Parti- cular.	Me- an.
Station at Weem, and top of Weem- craig, 700 $\frac{1}{4}$ feet.	1774, July 16. 11 ^h 30' A.M. bright Sun-shine.	29.996	69 $\frac{0}{2}$	-122	29.874	657.2	{ -43.2ft. = $\frac{65.3}{1000}$	65 $\frac{0}{2}$	62 $\frac{0}{2}$
		29.237	65 $\frac{3}{4}$	-107	29.130			60	
Ditto station, and top of Bolfrack's cairn, 1076 $\frac{1}{2}$ feet.	July 16. 6 ^h 30' P.M. calm and cloudy.	29.933	61 $\frac{3}{4}$	-097	29.836	1007.	{ -69.5 = 69.	60	58 $\frac{1}{2}$
		28.788	58 $\frac{1}{2}$	-083	28.705			56 $\frac{3}{4}$	
Ditto station, and top of Dull-craig, 1244 $\frac{3}{4}$ feet.	July 18. 7 ^h 20' A.M.	29.825	58 $\frac{1}{4}$	-086	29.739	1174.	{ -70.2 = 60.	57	56
		28.500	55	-072	28.428			55	
Ditto station, and top of Knock-farle, 1364 $\frac{1}{2}$ feet.	July 18. 5 ^h 4' A.M.	29.816	55 $\frac{3}{4}$	-077	29.739	1303.5	{ -61. = 46.8	54	51 $\frac{1}{4}$
		28.347	51	-059	28.288			48 $\frac{1}{2}$	
Ditto station, and that in Glenmore, 1279 $\frac{1}{4}$ feet.	July 12. 7 ^h 30' P.M.	29.528	58	-084	29.444	1216.5	{ -62.7 = 51.6	55	53 $\frac{1}{4}$
		28.161	51 $\frac{1}{4}$	-060	28.101			51 $\frac{1}{2}$	
Ditto station, and South observatory on Schihallien, 2098 ft.	July 11. 7 ^h 30' P.M.	29.643	58 $\frac{3}{4}$	-086	29.557	1989.8	{ -108.2 = 54.4	58	52 $\frac{1}{2}$
		27.432	48	-048	27.384			47 $\frac{3}{4}$	
Ditto station, and West summit of Schihallien, 3281 feet.	July 11. 7 ^h 30' A.M.	29.595	59 $\frac{1}{2}$	-089	29.506	3142.3	{ -138.7 = 44.1	56	50 $\frac{1}{2}$
		26.194	46	-040	26.154			45	
Station in Glenmore, and the South obser- vatory, 818 76.	July 12. 5 ^h A.M.	29.610	50 $\frac{3}{4}$	-062	29.548	3145.5	{ -135.5 = 43.1	50 $\frac{1}{4}$	46 $\frac{1}{8}$
		26.223	44	-035	26.188			42	
	July 12. 8 ^h P.M.	28.161	51 $\frac{1}{4}$	-060	28.101	777.4	{ -41.4 = 53.2	51 $\frac{1}{2}$	49 $\frac{3}{4}$
		27.325	48 $\frac{1}{2}$	-050	27.275			48	

The observation on Schihallien on July 11, by Mr. DE LUC's }
equation for the air, — — — — — } 3142.3 50°.5—39°.7=10°.8×2.1

N^o III. near Lanark.

Level of the Clyde at Lanark Bridge, and the station at the garden, 362 $\frac{1}{2}$ feet.	1774, Aug. 20. 6 ^h 30' A.M.	29.776	62 $\frac{1}{2}$	-099	29.677	342.9	{ -19.6 = 57.1	62	62
		29.383	61 $\frac{1}{4}$	-094	29.289			62	
		29.956	64 $\frac{3}{4}$	-107	29.849			63	
		29.563	65	-106	29.457			63	
		29.626	52 $\frac{1}{2}$	-067	29.559			52 $\frac{1}{2}$	
Level of the Clyde,	Sept. 5. 8 ^h A.M.	29.232	50 $\frac{1}{2}$	-060	29.172	343.4	{ -19.1 = 55.6	49 $\frac{1}{2}$	51
		29.864	50 $\frac{1}{2}$	-061	29.803			45	
		29.467	51	-062	29.405			44	
		29.886	50 $\frac{1}{2}$	-061	29.825			47	
		29.488	51 $\frac{1}{4}$	-063	29.425			41	

metrical observations made on heights near Taybridge in Perthshire;
and N° III. of those near Lanark.

N^o II. near Taybridge.

Temperature of the quicksilver.	Equation for the heat of the quick-silver.	Equated heights of the barometers.	Logarithmic result in feet.	Logar. excess or defect in ft. and also in 1000th parts.	Temperature of the air,		Equation by the rule in 1000th parts, and also in feet.	Result by the rule,		Error of the rule in feet.	Ratio of the weight of quick-silver to air, air being 1.
					Particular.	Mean.		Particular.	Mean.		
69 $\frac{1}{2}$	—122	29.874	} 657.2	{ — 43.2ft. = $\frac{65.3}{1000}$	65 $\frac{1}{2}$	62 $\frac{3}{4}$	{ + $\frac{27}{1000}$ = 50.8ft. }	707.8	— —	+ 7.6	11249
65 $\frac{3}{4}$	—107	29.130			60	58 $\frac{1}{2}$		{ + 67.5 = 68.5 }	1075.5	— —	— 1.
61 $\frac{3}{4}$	—097	29.836	} 1007.	{ — 69.5 = 69.	60	56 $\frac{3}{4}$	{ + 60. = 70.4 }	1244.4	— —	— —	11334
58 $\frac{1}{2}$	—083	28.705			57	55		{ + 47.5 = 62. }	1365.5	— —	+ 1.
58 $\frac{1}{4}$	—086	29.739	} 1174.	{ — 70.2 = 60.	54	51 $\frac{1}{4}$	{ + 52. = 63.2 }	1279.7	— —	— —	11396
55	—072	28.428			55	51 $\frac{1}{2}$		{ + 51. = 101.5 }	2091.3	— —	— 6.7
55 $\frac{3}{4}$	—077	29.739	} 1303.5	{ — 61. = 46.8	58	52 $\frac{1}{2}$	{ + 43.5 = 136.7 }	3279.	— —	— 2.	11693
51	—059	28.288			47 $\frac{3}{4}$	45		{ + 34.3 = 107. }	3252.5	— —	— 29.5
58	—084	29.444	} 1216.5	{ — 108.2 = 54.4	50 $\frac{1}{4}$	46 $\frac{1}{8}$	{ + 42. = 32.6 }	810.	— —	— 8.8	11851
51 $\frac{1}{4}$	—060	28.101			56	48		{ + 22.7 = 71.3 }	3213.6	— —	— 67.4
58 $\frac{3}{4}$	—086	29.557	} 1989.8	{ — 138.7 = 44.1	50 $\frac{1}{2}$	49 $\frac{3}{4}$	{ + 22.7 = 71.3 }	3213.6	— —	— 67.4	
48	—048	27.384			45	48					
59 $\frac{1}{2}$	—089	29.506	} 3142.3	{ — 135.5 = 43.1	50 $\frac{1}{4}$	46 $\frac{1}{8}$	{ + 34.3 = 107. }	3252.5	— —	— 29.5	11690
46	—040	26.154			42	48					
50 $\frac{3}{4}$	—062	29.548	} 3145.5	{ — 41.4 = 53.2	51 $\frac{1}{2}$	49 $\frac{3}{4}$	{ + 42. = 32.6 }	810.	— —	— 8.8	11851
44	—035	26.188			42	48					
51 $\frac{1}{4}$	—060	28.101	} 777.4	{ — 41.4 = 53.2	51 $\frac{1}{2}$	49 $\frac{3}{4}$	{ + 42. = 32.6 }	810.	— —	— 8.8	11851
48 $\frac{1}{2}$	—050	27.275			42	48					
by Mr. DE LUC's				3142.3	50°.5—39°.7=10°.8×2.1	{ + 22.7 = 71.3 }	3213.6	— —	— 67.4		

N^o III. near Lanark.

62 $\frac{1}{2}$	—099	29.677	} 342.9	{ —19.6 =57.1	62	} 62	{ + 74. =25.4	} 368.3	}	— — — — 11083		
61 $\frac{3}{4}$	—094	29.289			62							
64 $\frac{3}{4}$	—107	29.849	} 344.5	{ —18. =52.3	63	} 63	{ + 77.8 =26.8	} 371.3				
65	—106	29.457			63							
52 $\frac{1}{2}$	—067	29.559	} 343.4	{ —19.1 =55.6	52 $\frac{1}{2}$	} 51	{ + 46. =15.8	} 359.2			}	364.4 + 1.9 11182
50 $\frac{1}{2}$	—060	29.172			49 $\frac{1}{2}$							
50 $\frac{1}{2}$	—061	29.803	} 350.3	{ —12.2 =34.8	45	} 44 $\frac{1}{2}$	{ + 30.5 =10.7	} 361 0	}	— — — — 10875		
51	—062	29.405			44							
50 $\frac{1}{2}$	—061	29.825	} 351.8	{ —10.7 =30.4	47	} 44	{ + 29. =10.2	} 362 0				
51 $\frac{1}{4}$	—063	29.425			41							
48 $\frac{1}{2}$	—055	29.817	} 342.9	{ —19.6 =57.1	62	} 62	{ + 74. =25.4	} 368.3			}	— — — — 11083
61 $\frac{3}{4}$	—094	29.289			62							

1279 $\frac{1}{4}$ feet. Ditto station, and South observatory on Schihallien, 2098 ft.	July 11. 7 ^h 30' P.M.	{	29.643	58 $\frac{3}{4}$	—086	29.557	1989.8	{	—108.2	58	52 $\frac{1}{2}$
			27.432	48	—048	27.384			= 54.4	47 $\frac{3}{4}$	
Ditto station, and West summit of Schihallien, 3281 feet.	July 11. 7 ^h 30' A.M.	{	29.595	59 $\frac{1}{2}$	—089	29.506	3142.3	{	—138.7	56	50 $\frac{1}{2}$
			26.194	46	—040	26.154			= 44.1	45	
Station in Glenmore, and the South obser- vatory, 818 76.	July 12. 5 ^h A.M.	{	29.610	50 $\frac{3}{4}$	—062	29.548	3145.5	{	—135.5	50 $\frac{1}{4}$	46 $\frac{1}{8}$
			26.223	44	—035	26.188			= 43.1	42	
	July 12. 8 ^h P.M.	{	28.161	51 $\frac{1}{4}$	—060	28.101	777.4	{	—41.4	51 $\frac{1}{2}$	49 $\frac{3}{4}$
			27.325	48 $\frac{1}{2}$	—050	27.275			= 53.2	48	

The observation on Schihallien on July 11, by Mr. DE LUC's } 3142.3 50°.5—39°.7=10°.8×2.1
equation for the air, — — —

N° III. near Lanark.

Level of the Clyde at Lanark Bridge, and the station at the garden, 362 $\frac{1}{2}$ feet.	1774, Aug. 20. 6 ^h 30' A.M.	{	29.776	62 $\frac{1}{2}$	—099	29.677	342.9	{	—19.6	62	62
			29.383	61 $\frac{3}{4}$	—094	29.289			= 57.1	62	
	Aug. 23. 3 ^h 8' P.M.	{	29.956	64 $\frac{3}{4}$	—107	29.849	344.5	{	—18.	63	63
			29.563	65	—106	29.457			= 52.3	63	
	Sept. 5. 8 ^h A.M.	{	29.626	52 $\frac{1}{2}$	—067	29.559	343.4	{	—19.1	52 $\frac{1}{2}$	51
			29.232	50 $\frac{1}{2}$	—060	29.172			= 55.6	49 $\frac{1}{2}$	
Level of the Clyde, and Stonebyre-hill, 654 feet.	Sept. 7. 7 ^h 47' A.M.	{	29.864	50 $\frac{1}{2}$	—061	29.803	350.3	{	—12.2	45	44 $\frac{1}{2}$
			29.467	51	—062	29.405			= 34.8	44	
	Sept. 7. 9 ^h A.M.	{	29.886	50 $\frac{1}{2}$	—061	29.825	351.8	{	—10.7	47	44
			29.488	51 $\frac{1}{4}$	—063	29.425			= 30.4	41	
Carmichael-well, and West-end of Carmichael-hill, 451 $\frac{1}{2}$ feet.	Sept. 7. 8 ^h 15' A.M.	{	29.872	48 $\frac{1}{2}$	—055	29.817	631.6	{	—22.4	46 $\frac{3}{4}$	45 $\frac{1}{4}$
			29.148	46 $\frac{1}{4}$	—045	29.103			= 35.4	45 $\frac{3}{4}$	
Carmichael-well, and top of Tinto, four feet below the summit of the Cairn, 1642.5 ft.	July 30. 5 ^h 40' P.M. S.W. wind, begin- ning to rain.	{	29.162	56	—076	29.086	421.8	{	—29.7	54 $\frac{3}{4}$	54
			28.690	54 $\frac{1}{2}$	—071	28.619			= 70.3	53 $\frac{1}{4}$	
	Aug. 1. 11 ^h 40' A.M.	{	29.612	58 $\frac{3}{4}$	—086	29.526	427.1	{	—24.4	57	55 $\frac{7}{8}$
			29.135	60	—089	29.046			= 57.1	54 $\frac{3}{4}$	
	June 30. 1 ^h 30' P.M.	{	28.991	61 $\frac{1}{4}$	—093	28.898	1563.6	{	—78.9	58	54 $\frac{1}{2}$
			27.284	55 $\frac{1}{4}$	—069	27.215			= 50.5	51	
	July 30. 6 ^h A.M.	{	29.063	51 $\frac{1}{2}$	—062	29.001	1582.6	{	—59.9	51	47 $\frac{1}{2}$
			27.335	46 $\frac{1}{4}$	—043	27.292			= 38.	44	
	Aug. 2. 8 ^h 15' A.M.	{	29.608	54 $\frac{1}{4}$	—072	29.536	1580.3	{	—62.2	51 $\frac{1}{2}$	48
			27.846	47 $\frac{1}{2}$	—048	27.798			= 39.3	44 $\frac{1}{2}$	
	Aug. 27. 11 ^h 50' A.M. S.W. wind.	{	28.710	59 $\frac{3}{4}$	—087	28.623	1570.3	{	—72.2	55 $\frac{3}{4}$	51 $\frac{1}{2}$
			27.008	53 $\frac{1}{4}$	—063	26.945			= 46.	47 $\frac{1}{4}$	
	Aug. 27. 1 ^h 40' P.M. hail.	{	28.736	60 $\frac{3}{4}$	—090	28.646	1571.	{	—71.5	55 $\frac{1}{4}$	52 $\frac{3}{4}$
			27.032	53	—062	26.970			= 45.5	50	
	Aug. 27. 1 ^h 50' P.M.	{	28.716	58 $\frac{1}{2}$	—083	28.633	1579.5	{	—63.	55 $\frac{1}{4}$	52
			27.010	52 $\frac{1}{4}$	—061	26.949			= 40.	48 $\frac{3}{4}$	

Mean of the observations on Tinto, with Mr. DE LUC's equation } 1574.5 51°—39°.7=11.3×2.1
for the air, — — —

3	58 $\frac{3}{4}$	—086	29.557	1989.8	{ —108.2	58	52 $\frac{1}{2}$	{ + 51.	2091.3	—	—	— 6.7	11554
2	48 $\frac{1}{2}$	—048	27.384		{ = 54.4	47 $\frac{3}{4}$		{ = 101.5					
5	59 $\frac{1}{2}$	—089	29.506	3142.3	{ —138.7	56	50 $\frac{1}{2}$	{ + 43.5	3279.	—	—	— 2.	11693
4	46	—040	26.154		{ = 44.1	45		{ = 136.7					
0	50 $\frac{3}{4}$	—062	29.548	3145.5	{ —135.5	50 $\frac{1}{4}$	46 $\frac{1}{8}$	{ + 34.3	3252.5	—	—	—29.5	11690
3	44	—035	26.188		{ = 43.1	42		{ = 107.					
1	51 $\frac{1}{4}$	—060	28.101	777.4	{ — 41.4	51 $\frac{1}{2}$	49 $\frac{3}{4}$	{ + 42.	810.	—	—	— 8.8	11851
4	48 $\frac{1}{2}$	—050	27.275		{ = 53.2	48		{ = 32.6					
by Mr. DE LUC's				3142.3	50°.5—39°.7=10°.8×2.1	{ + 22.7	3213.6	{ = 71.3		—	—	—67.4	

N° III. near Lanark.

6	62 $\frac{1}{2}$	—099	29.677	342.9	{ —19.6	62	62	{ + 74.	368.3	}	—	—	—	11083
3	61 $\frac{1}{4}$	—094	29.289		{ = 57.1	62		{ = 25.4						
6	64 $\frac{3}{4}$	—107	29.849	344.5	{ —18.	63	63	{ + 77.8	371.3					
3	65	—106	29.457		{ = 52.3	63		{ = 26.8		}	364.4	+ 1.9	11182	11083
5	52 $\frac{1}{2}$	—067	29.559	343.4	{ —19.1	52 $\frac{1}{2}$	51	{ + 46.	359.2					
0	50 $\frac{1}{2}$	—060	29.172		{ = 55.6	49 $\frac{1}{2}$		{ = 15.8						
4	50 $\frac{1}{2}$	—061	29.803	350.3	{ —12.2	45	44 $\frac{1}{2}$	{ + 30.5	361 0	}	—	—	—	10875
7	51	—062	29.405		{ = 34.8	44		{ = 10.7						
6	50 $\frac{1}{2}$	—061	29.825	351.8	{ —10.7	47	44	{ + 29.	362 0					
3	51 $\frac{1}{4}$	—063	29.425		{ = 30.4	41		{ = 10.2		}	—	—	—	10946
2	48 $\frac{1}{2}$	—055	29.817	631.6	{ —22.4	46 $\frac{3}{4}$	45 $\frac{1}{4}$	{ + 32.3	652.					
8	46 $\frac{3}{4}$	—045	29.103		{ = 35.4	45 $\frac{3}{4}$		{ = 20.4						
2	56	—076	29.086	421.8	{ —29.7	54 $\frac{3}{4}$	54	{ + 52.3	443.8	}	—	—	—7.7	11430
0	54 $\frac{1}{2}$	—071	28.619		{ = 70.3	53 $\frac{1}{4}$		{ = 22.						
2	58 $\frac{3}{4}$	—086	29.526	427.1	{ —24.4	57	55 $\frac{7}{8}$	{ + 57.1	451.5					
5	60	—089	29.046		{ = 57.1	54 $\frac{3}{4}$		{ = 24.4		}	—	—	—	11684
1	61 $\frac{1}{4}$	—093	28.898	1563.6	{ —78.9	58	54 $\frac{1}{2}$	{ + 53.	1646 9					
4	55 $\frac{1}{4}$	—069	27.215		{ = 50.5	51		{ = 83.3						
3	51 $\frac{1}{2}$	—062	29.001	1582.6	{ —59.9	51	47 $\frac{1}{2}$	{ + 36.4	1640.	}	—	—	—	11412
5	46 $\frac{1}{4}$	—043	27.292		{ = 38.	44		{ = 57.4						
8	54 $\frac{1}{4}$	—072	29.536	1580.3	{ —62.2	51 $\frac{1}{2}$	48	{ + 39.6	1642.7					
6	47 $\frac{1}{2}$	—048	27.798		{ = 39 3	44 $\frac{1}{2}$		{ = 62.4		}	1645.5	+ 3.0	—	11704
0	59 $\frac{3}{4}$	—087	28.623	1570.3	{ —72.2	55 $\frac{3}{4}$	51 $\frac{1}{2}$	{ + 45.6	1642.6					
8	53 $\frac{1}{4}$	—063	26.945		{ = 46.	47 $\frac{1}{4}$		{ = 72.3						
6	60 $\frac{3}{4}$	—090	28.646	1571.	{ —71.5	55 $\frac{1}{4}$	52 $\frac{3}{4}$	{ + 49.	1647.8	}	—	—	—	11704
2	53	—062	26.970		{ = 45.5	50		{ = 76.8						
6	58 $\frac{1}{2}$	—083	28.633	1579.5	{ —63.	55 $\frac{1}{4}$	52	{ + 46.4	1652.8					
0	52 $\frac{1}{4}$	—061	26.949		{ = 40.	48 $\frac{3}{4}$		{ = 73.3		}	—	—	—29.	3
DE LUC's equation				1574.5	51°—39°.7=11.3×2.1	{ + 24.8	1613.5	{ = 39.						
						{ = 39.								

N° IV. Computations of barometrical observations on height

Geometrical heights of the stations in feet.	Date of the observations, winds, &c.	Observed heights of the inferior and superior barometers.	Temperature of the quicksilver.	Equation for the heat of the quicksilver.	Equated heights of the barometers.	Logarithmic result in feet.	Logar. excess or defect in ft. and also in 1000th parts.	Temperature of the air	
								Particular.	Mean.
Leith Pier-head, and Calton-hill, 344 feet.	1774, Aug. 12. 5 ^h 20' A.M. }	30.086 29.704	52° $\frac{1}{2}$ 49 $\frac{3}{4}$	—067 —058	30.019 29.646	325.8	{ —18.2ft. = $\frac{50}{1000}$	50° $\frac{3}{4}$ 49	50
	Aug. 15. 6 ^h 45' A.M. }	29.568 29.197	55 $\frac{1}{4}$ 53 $\frac{1}{2}$	—075 —068	29.493 29.129	323.6	{ —20.4 =60.3	54 54 $\frac{1}{2}$	54 $\frac{1}{2}$
	Aug. 15. 0 ^h 15' P.M. S.W. wind and rain. }	29.625 29.282	56 $\frac{1}{4}$ 53 $\frac{1}{2}$	—078 —068	29.547 29.214	319.1	{ —24.9 =78.	54 54 $\frac{1}{2}$	54 $\frac{1}{4}$
Leith Pier-head, and top of Arthur's Seat, 803 feet.	Aug. 15. 5 ^h 15' A.M. S.W. wind and rain. }	29.567 28.704	55 $\frac{1}{4}$ 51 $\frac{3}{4}$	—075 —062	29.492 28.642	762.	{ —41. =53.8	54 50 $\frac{1}{2}$	52 $\frac{1}{4}$
Leith Pier-head, and Kirk Yetton cairn, 1544 feet.	Sept. 15. 10 ^h 30' A.M. S.W. wind. }	29.953 28.291	57 $\frac{1}{2}$ 52 $\frac{1}{4}$	—084 —063	29.869 28.228	1472.5	{ —71.5 =48.6	54 $\frac{1}{2}$ 47 $\frac{1}{4}$	51
Calton-hill, and Kirk-Yetton cairn, 1200 feet.	Sept. 15. 1 ^h 15' P.M. S.W. wind. }	29.561 28.272	63 $\frac{3}{4}$ 54	—100 —068	29.461 28.204	1136.2	{ —63.8 =56.2	56 $\frac{1}{2}$ 48 $\frac{1}{2}$	52 $\frac{1}{2}$
Level of Hawk-hill study, and bottom of Small rock, 7.4 ft. below the top of Arthur's Seat, 702.4 feet.	1774, Dec. 1. 2 ^h 45' P.M. }	29.565 28.770	35 32	—010 —	29.555 28.770	701.5	{ — 0 9 = 1.3	33 30 $\frac{1}{2}$	31 $\frac{3}{4}$
	Dec. 10. 9 ^h 46' A.M. }	29.494 28.687	20 $\frac{1}{2}$ 20 $\frac{1}{2}$	+038 +037	29.532 28.724	722.9	{ +20.5 =28.3	20 $\frac{1}{2}$ 20 $\frac{1}{2}$	20 $\frac{1}{2}$
	1775, Jan. 26. 1 ^h 35' P.M. }	29.490 28.674	26 $\frac{1}{2}$ 24 $\frac{3}{4}$	+018 +026	29.508 28.700	723.5	{ +21.1 =29.	26 23	24 $\frac{1}{2}$
Base of Hawk-hill observatory, and bottom of the Small-rock on Arthur's Seat, 684 feet.	Nov. 10. 11 ^h 30' A.M. }	29.959 29.177	38 34	—020 —006	29.939 29.171	677.2	{ — 6.8 =10.	36 $\frac{3}{4}$ 34	35 $\frac{1}{2}$
	Nov. 17. 9 ^h 30' A.M. }	29.543 28.769	33 $\frac{1}{4}$ 30 $\frac{1}{4}$	—004 +005	29.539 28.774	683.8	{ — =	32 29 $\frac{1}{4}$	30 $\frac{5}{8}$
	1776, Jan. 31. 10 ^h 45' A.M. }	30.009 29.229	15 $\frac{1}{2}$ 24	+056 +026	30.065 29.225	711.7	{ +27.7 =39.	14 20	17
	July 25. 2 ^h 20' P.M. }	30.157 29.427	70 $\frac{1}{4}$ 66 $\frac{1}{2}$	—125 —111	30.032 29.316	628.8	{ —55.2 =87.7	69 $\frac{3}{4}$ 67	68 $\frac{1}{2}$
Hawk-hill garden-door, and bottom of the rock on Arthur's Seat, 730.8 feet.	1775, Dec. 27. 11 ^h 30' A.M. }	29.807 28.985	30 $\frac{3}{4}$ 29 $\frac{3}{4}$	+004 +007	29.811 28.992	725.9	{ — 4.9 = 6.7	29 $\frac{1}{2}$ 29 $\frac{1}{2}$	29 $\frac{1}{2}$
	Dec. 27. 8 ^h 40' A.M. }	29.778 28.945	35 $\frac{3}{4}$ 33	—013 —003	29.765 28.942	730.6	{ — =	35 $\frac{3}{4}$ 32 $\frac{1}{2}$	34 $\frac{1}{4}$
	1776, Feb. 1. 9 ^h 30' A.M. }	29.883 29.032	28 $\frac{3}{4}$ 26 $\frac{1}{2}$	+011 +019	29.894 29.051	745.4	{ +14.6 =19.6	24 $\frac{1}{2}$ 26 $\frac{1}{2}$	25 $\frac{1}{2}$
	Aug. 3. 2 ^h 20' P.M. }	30.135 29.348	75 $\frac{1}{2}$ 72	—141 —127	29.994 29.221	680.4	{ —50.4 =74.	72 $\frac{3}{4}$ 69	73 $\frac{3}{4}$

ons of barometrical observations on heights near Edinburgh.

Barometers.	Temperature of the quicksilver.	Equation for the heat of the quicksilver.	Equated heights of the barometers.	Logarithmic result in feet.	Logar. excess or defect in ft. and also in 100th parts.	Temperature of the air,		Equation by the rule in 100th parts, and also in feet.	Result by the rule,		Error of the rule in feet.	Ratio of the weight of quicksilver to air, being 1.
						Particular.	Mean.		Particular.	Mean.		
86 04	52° $\frac{1}{2}$ 49° $\frac{3}{4}$	—067 —058	30.019 29.646	325.8	{ —18.2 ft. = $\frac{36}{1000}$	50° $\frac{3}{4}$ 49	50°	{ + $\frac{47}{1000}$ = 15.3 f.	341.1	— —	— —	11037
68 97	55° $\frac{1}{4}$ 53° $\frac{1}{2}$	—075 —068	29.493 29.129	323.6	{ —20.4 = 60.3	54 54 $\frac{1}{2}$	54 $\frac{1}{4}$	{ + 54. = 17.5	341.1	339.5	—4.5	11761
25 82	56° $\frac{1}{4}$ 53° $\frac{1}{2}$	—078 —068	29.547 29.214	319.1	{ —24.9 = 78.	54 54 $\frac{1}{2}$	54 $\frac{1}{4}$	{ + 54. = 17.2	336.3	— —	— —	11309
67 04	55° $\frac{1}{4}$ 51° $\frac{3}{4}$	—075 —062	29.492 28.642	762.	{ —41. = 53.8	54 50 $\frac{1}{2}$	52 $\frac{1}{4}$	{ + 50. = 38.	800.	— —	—3.	11309
53 91	57° $\frac{1}{2}$ 52° $\frac{1}{4}$	—084 —063	29.869 28.228	1472.5	{ —71.5 = 48.6	54 $\frac{1}{2}$ 47 $\frac{1}{4}$	51	{ + 47. = 69.2	1541.7	— —	—2.3	11249
61 72	63° $\frac{1}{4}$ 54	—100 —068	29.461 28.204	1136.2	{ —63.8 = 56.2	56 $\frac{1}{2}$ 48 $\frac{1}{2}$	52 $\frac{1}{2}$	{ + 52. = 59.	1195.2	— —	—4.8	11410
65 70	35 32	—010 —	29.555 28.770	701.5	{ — 0.9 = 1.3	33 30 $\frac{1}{2}$	31 $\frac{3}{4}$	{ — 0.5 = 0.3	701.2	— —	— —	10724
94 87	20° $\frac{1}{2}$ 20° $\frac{1}{2}$	+038 +037	29.532 28.724	722.9	{ + 20.5 = 28.3	20° $\frac{1}{2}$ 20° $\frac{1}{2}$	20° $\frac{1}{2}$	{ —26.6 = 19.2	703.7	705.3	+2.9	11445
90 74	26° $\frac{1}{2}$ 24° $\frac{1}{4}$	+018 +026	29.508 28.700	723.5	{ + 21.1 = 29.	26 23	24 $\frac{1}{2}$	{ —17. = 12.4	711.1	— —	— —	10419
59 77	38 34	—020 —006	29.939 29.171	677.2	{ — 6.8 = 10.	36 $\frac{3}{4}$ 34	35 $\frac{1}{2}$	{ + 8.6 = 5.8	683.	— —	— —	10646
43 69	33° $\frac{1}{4}$ 30° $\frac{1}{4}$	—004 +005	29.539 28.774	683.8	{ — = —	32 29 $\frac{1}{4}$	30° $\frac{5}{8}$	{ — 3.5 = 2.4	681.4	684.5	+0.5	10729
09 29	15° $\frac{1}{2}$ 24	+056 +026	30.065 29.225	711.7	{ + 27.7 = 39.	14 20	17	{ —35.2 = 25.	686.7	— —	— —	10184
57 27	70° $\frac{1}{4}$ 66° $\frac{1}{2}$	—125 —111	30.032 29.316	628.8	{ —55.2 = 87.7	69 $\frac{3}{4}$ 67	68 $\frac{1}{2}$	{ + 94. = 58.2	687.0	— —	— —	11416
07 85	30° $\frac{3}{4}$ 29° $\frac{3}{4}$	+004 +007	29.811 28.992	725.9	{ — 4.9 = 6.7	29° $\frac{1}{2}$ 29° $\frac{1}{2}$	29° $\frac{1}{2}$	{ — 5.7 = 4.1	721.8	— —	— —	10707
78 45	35° $\frac{3}{4}$ 33	—013 —003	29.765 28.942	730.6	{ — = —	35° $\frac{3}{4}$ 32° $\frac{1}{2}$	34° $\frac{1}{4}$	{ + 5.4 = 4.	734.6	734.7	+3.9	10642
83 32	28° $\frac{3}{4}$ 26° $\frac{1}{2}$	+011 +019	29.894 29.051	745.4	{ + 14.6 = 19.6	24° $\frac{1}{2}$ 26° $\frac{1}{2}$	25° $\frac{1}{2}$	{ + 15.4 = 11.5	733.9	— —	— —	10390
35 48	75° $\frac{1}{2}$ 72	—141 —127	29.994 29.221	680.4	{ —50.4 = 74.	72° $\frac{3}{4}$ 69	73° $\frac{3}{4}$	{ + 100. = 68.	748.4	— —	— —	11286

Geometrical heights of the stations in feet.	Date of the obser- vations, winds, &c.	Observed height of the inferior and superior rometers.	Temperature the quicksilver in the Equation for heat of the equi- valent.	Equated height of the baro- meters.	Logarithm result in feet.	Logar. exc or defect ft. and also 1000th part	Parti- cular.	M	
Leith Pier-head, and Calton-hill, 344 feet.	1774, Aug. 12. 5 ^h 20' A.M. }	30.086 29.704	52° $\frac{1}{2}$ 49 $\frac{3}{4}$	—067 —058	30.019 29.646	325.8 {	—18.2ft. = $\frac{56}{1000}$	50° $\frac{3}{4}$ 49	50
	Aug. 15. 6 ^h 45' A.M. }	29.568 29.197	55 $\frac{1}{4}$ 53 $\frac{1}{2}$	—075 —068	29.493 29.129	323.6 {	—20.4 = 60.3	54 54 $\frac{1}{2}$	54 $\frac{1}{2}$
	Aug. 15. 0 ^h 15' P.M. S.W. wind and rain. }	29.625 29.282	56 $\frac{1}{4}$ 53 $\frac{1}{2}$	—078 —068	29.547 29.214	319.1 {	—24.9 = 78.	54 54 $\frac{1}{2}$	54 $\frac{1}{2}$
Leith Pier-head, and top of Arthur's Seat, 803 feet.	Aug. 15. 5 ^h 15' A.M. S.W. wind and rain. }	29.567 28.704	55 $\frac{1}{4}$ 51 $\frac{3}{4}$	—075 —062	29.492 28.642	762. {	—41. = 53.8	54 50 $\frac{1}{2}$	52 $\frac{3}{4}$
Leith Pier-head, and Kirk Yetton cairn, 1544 feet.	Sept. 15. 10 ^h 30' A.M. S.W. wind. }	29.953 28.291	57 $\frac{1}{2}$ 52 $\frac{3}{4}$	—084 —063	29.869 28.228	1472.5 {	—71.5 = 48.6	54 $\frac{1}{2}$ 47 $\frac{1}{4}$	51
Calton-hill, and Kirk- Yetton cairn, 1200 feet.	Sept. 15. 1 ^h 15' P.M. S.W. wind. }	29.561 28.272	63 $\frac{1}{4}$ 54	—100 —068	29.461 28.204	1136.2 {	—63.8 = 56.2	56 $\frac{1}{2}$ 48 $\frac{1}{2}$	52 $\frac{1}{2}$
Level of Hawk-hill study, and bottom of Small rock, 7.4 ft. below the top of Arthur's Seat, 702.4 feet.	1774, Dec. 1. 2 ^h 45' P.M. }	29.565 28.770	35 32	—010 —	29.555 28.770	701.5 {	— 09 = 1.3	33 30 $\frac{1}{2}$	31 $\frac{3}{4}$
	Dec. 10. 9 ^h 46' A.M. }	29.494 28.687	20 $\frac{1}{2}$ 20 $\frac{1}{2}$	+038 +037	29.532 28.724	722.9 {	+20.5 = 28.3	20 $\frac{1}{2}$ 20 $\frac{1}{2}$	20 $\frac{1}{2}$
	1775, Jan. 26. 1 ^h 35' P.M. }	29.490 28.674	26 $\frac{1}{2}$ 24 $\frac{1}{4}$	+018 +026	29.508 28.700	723.5 {	+21.1 = 29.	26 23	24 $\frac{1}{2}$
Base of Hawk-hill observatory, and bottom of the Small-rock on Arthur's Seat, 684 feet.	Nov. 10. 11 ^h 30' A.M. }	29.959 29.177	38 34	—020 —006	29.939 29.171	677.2 {	— 6.8 = 10.	36 $\frac{3}{4}$ 34	35 $\frac{1}{2}$
	Nov. 17. 9 ^h 30' A.M. }	29.543 28.769	33 $\frac{1}{4}$ 30 $\frac{3}{4}$	—004 +005	29.539 28.774	683.8 {	— —	32 29 $\frac{1}{4}$	30 $\frac{3}{8}$
	1776, Jan. 31. 10 ^h 45' A.M. }	30.009 29.229	15 $\frac{1}{2}$ 24	+056 +026	30.065 29.225	711.7 {	+27.7 = 39.	14 20	17
	July 25. 2 ^h 20' P.M. }	30.157 29.427	70 $\frac{1}{4}$ 66 $\frac{1}{2}$	—125 —111	30.032 29.316	628.8 {	—55.2 = 87.7	69 $\frac{3}{4}$ 67	68 $\frac{1}{2}$
Hawk-hill garden- door, and bottom of the rock on Ar- thur's Seat, 730.8 feet.	1775, Dec. 27. 11 ^h 30' A.M. }	29.807 28.985	30 $\frac{3}{4}$ 29 $\frac{3}{4}$	+004 +007	29.811 28.992	725.9 {	— 4.9 = 6.7	29 $\frac{1}{2}$ 29 $\frac{1}{2}$	29 $\frac{1}{2}$
	Dec. 27. 8 ^h 40' A.M. }	29.778 28.945	35 $\frac{1}{4}$ 33	—013 —003	29.765 28.942	730.6 {	— —	35 $\frac{3}{4}$ 32 $\frac{1}{2}$	34 $\frac{1}{4}$
	1776, Feb. 1. 9 ^h 30' A.M. }	29.883 29.032	28 $\frac{3}{4}$ 26 $\frac{1}{2}$	+011 +019	29.894 29.051	745.4 {	+14.6 = 19.6	24 $\frac{1}{2}$ 26 $\frac{1}{2}$	25 $\frac{1}{2}$
	Aug. 3. 2 ^h 20' P.M. }	30.135 29.348	75 $\frac{1}{2}$ 72	—141 —127	29.994 29.221	680.4 {	—50.4 = 74.	72 $\frac{3}{4}$ 69	73 $\frac{3}{4}$

In these two last observations Mr. DE LUC's equation
for the air being substituted,

1776, Feb. 1. 745.4 39°.7—25°.5=14°.2 × 2.

Aug. 3. 680.4 70°.7—39°.7=31°. × 2.

Barometers. inches.	Temperature the quickfil mer.	Equation for heat of the qui silver.	Equated height of the barom- eters.	Logarithm result in fe- et.	Logar. exc. or defect ft. and alto- gether par- 1000th part.	of the air,		Equation by rule in 100 parts, and in feet.	the rule in feet.		Ratio of weight of quick- silver to air, being 1.
						Partic- ular.	Mean.		Particu- lar.	Mean.	
86 04	52 $\frac{1}{2}$ 49 $\frac{3}{4}$	-067 -058	30.019 29.646	} 325.8	{ -18.2ft. = $\frac{36}{1000}$	50 $\frac{3}{4}$ 49	50°	{ + $\frac{47}{1000}$ = 15.3f. }	341.1	- -	11037
68 97	55 $\frac{1}{4}$ 53 $\frac{1}{2}$	-075 -068	29.493 29.129	} 323.6	{ -20.4 = 60.3	54 54 $\frac{1}{2}$	54 $\frac{1}{4}$	{ + 54. = 17.5 }	341.1	339.5	-4.5
25 82	56 $\frac{1}{4}$ 53 $\frac{1}{2}$	-078 -068	29.547 29.214	} 319.1	{ -24.9 = 78.	54 54 $\frac{1}{2}$	54 $\frac{1}{4}$	{ + 54. = 17.2 }	336.3	- -	11761
67 04	55 $\frac{1}{4}$ 51 $\frac{3}{4}$	-075 -062	29.492 28.642	} 762.	{ -41. = 53.8	54 50 $\frac{1}{2}$	52 $\frac{1}{4}$	{ + 50. = 38. }	800.	- -	11309
53 91	57 $\frac{1}{2}$ 52 $\frac{1}{4}$	-084 -063	29.869 28.228	} 1472.5	{ -71.5 = 48.6	54 $\frac{1}{2}$ 47 $\frac{1}{4}$	51	{ + 47. = 69.2 }	1541.7	- -	11249
61 72	63 $\frac{1}{4}$ 54	-100 -068	29.461 28.204	} 1136.2	{ -63.8 = 56.2	56 $\frac{1}{2}$ 48 $\frac{1}{2}$	52 $\frac{1}{2}$	{ + 52. = 59. }	1195.2	- -	11410
65 70	35 32	-010 —	29.555 28.770	} 701.5	{ - 0.9 = 1.3	33 30 $\frac{1}{2}$	31 $\frac{3}{4}$	{ - 0.5 = 0.3 }	701.2	- -	10724
94 87	20 $\frac{1}{2}$ 20 $\frac{1}{2}$	+038 +037	29.532 28.724	} 722.9	{ + 20.5 = 28.3	20 $\frac{1}{2}$ 20 $\frac{1}{2}$	20 $\frac{1}{2}$	{ -26.6 = 19.2 }	703.7	705.3	+2.9
90 74	26 $\frac{1}{2}$ 24 $\frac{1}{4}$	+018 +026	29.508 28.700	} 723.5	{ + 21.1 = 29.	26 23	24 $\frac{1}{2}$	{ -17. = 12.4 }	711.1	- -	10419
59 77	38 34	-020 -006	29.939 29.171	} 677.2	{ - 6.8 = 10.	36 $\frac{3}{4}$ 34	35 $\frac{1}{2}$	{ + 8.6 = 5.8 }	683.	- -	10646
43 69	33 $\frac{1}{4}$ 30 $\frac{1}{4}$	-004 +005	29.539 28.774	} 683.8	{ — —	32 29 $\frac{1}{4}$	30 $\frac{5}{8}$	{ - 3.5 = 2.4 }	681.4	- -	10729
09 29	15 $\frac{1}{2}$ 24	+056 +026	30.065 29.225	} 711.7	{ + 27.7 = 39.	14 20	17	{ -35.2 = 25. }	686.7	684.5	+0.5
57 27	70 $\frac{1}{4}$ 66 $\frac{1}{2}$	-125 -111	30.032 29.316	} 628.8	{ -55.2 = 87.7	69 $\frac{3}{4}$ 67	68 $\frac{1}{2}$	{ + 94. = 58.2 }	687.0	- -	11416
07 85	30 $\frac{3}{4}$ 29 $\frac{3}{4}$	+004 +007	29.811 28.992	} 725.9	{ - 4.9 = 6.7	29 $\frac{1}{2}$ 29 $\frac{1}{2}$	29 $\frac{1}{2}$	{ - 5.7 = 4.1 }	721.8	- -	10707
78 45	35 $\frac{3}{4}$ 33	-013 -003	29.765 28.942	} 730.6	{ — —	35 $\frac{3}{4}$ 32 $\frac{1}{2}$	34 $\frac{1}{4}$	{ + 5.4 = 4. }	734.6	- -	10642
83 32	28 $\frac{3}{4}$ 26 $\frac{1}{2}$	+011 +019	29.894 29.051	} 745.4	{ + 14.6 = 19.6	24 $\frac{1}{2}$ 26 $\frac{1}{2}$	25 $\frac{1}{2}$	{ + 15.4 = 11.5 }	733.9	734.7	+3.9
35 48	75 $\frac{1}{2}$ 72	-141 -127	29.994 29.221	} 680.4	{ -50.4 = 74.	72 $\frac{3}{4}$ 69	73 $\frac{3}{4}$	{ + 100. = 68. }	748.4	- -	11286
Equation { 1776, Feb. 1. 745.4 39°.7—25°.5=14°.2 × 2.1								{ -29.8 = 22.2 }	723.2	- -	-7.6
								{ + 65.1 = 44.3 }	724.7	- -	-6.1

N° V. Computations of barometrical observations made on h
and N° VI. of those near Carnarvon in North V

N° V. near Linhouse.										
Geometrical heights of the stations in feet.	Date of the observa- tions, winds, &c.	Observed heights of the inferior and superior ba- rometers.	Temperature of the quicksilver,	Equation for the heat of the quick- silver.	Equated heights of the barome- ters.	Logarithmic result in feet.	Logar. excess or defect in ft. and also in 1000th parts.	Temperature of the air,		
								Parti- cular.	Mea-	
Linhouse and East- cairn hill, 5 feet below the summit, 1176.6 feet.	1775, Nov 11. 8 ^h A.M. calm and clear.	29.216 27.912	32° 30	— +006	29.216 27.918	1184.2	{ +7.6 ft. = $\frac{64}{1000}$	32° 29	30° $\frac{1}{2}$	
	Nov. 15. noon.	28.941 27.632	32 27	— +015	28.941 27.647	1191.9	{ + 15.3 = 12.8	32 26	29	
Linhouse, and East- cairn hill, 18 feet below the top, 1165.6 feet.	1776, Dec. 17. 2 ^h P.M.	28.990 27.688	31½ 24	+001 +025	28.991 27.713	1174.8	{ + 9.2 = 7.9	30¼ 22	26½	
	Substituting Mr. DE LUC's equation for the air, — 39°.7—26°.1=13°.6×2.1									
Linhouse, and West- cairn hill, 11 ft. be- low the top, 1178.4 ft.	1775, Dec. 1. 1 ^h P.M. high S.W.	29.250 28.003	49 45	—055 —042	29.195 27.961	1125.3	{ — 53.2 = 47.3	48° 45	46° $\frac{1}{2}$	
	Dec. 8. 1 ^h P.M. clear and windy.	29.686 29.521	41 39	—029 —023	29.657 29.288	379.7	{ — 6.8 = 18.	40 39	39½	
Corston hill, and West-cairn hill, 792 feet.	1776, Dec. 16 ^h 11' A.M. high N. wind, clear weather.	28.580 27.714	34¾ 32	—009 —	28.571 27.714	793.6	{ + 1.6 = 2.	34¼ 30	32½	
	Dec. 17. 1 ^h A.M. light W. wind.	28.574 27.710	32 25	— +022	28.574 27.732	779.4	{ + 2.8 = 3.6	31 23½	27¼	
Corston hill, and East cairn hill, 776.6 feet.	Nov. 20. 1 ^h P.M. snow had fallen, high W. wind.	27.992 27.582	35 33	—009 —003	27.983 27.579	379.	{ — 9.5 = 28.2	33 33	33	

N° VI. near Carnarvon.

Carnarvon Quay, and Moel Eilio, 2371 feet.	1775, Aug. 4. 1 ^h 7' P.M. rain above, clear below.	29.693 27.714	62½ 54	—098 —066	29.595 27.148	2248.8	{ —122.2 + 54.4	62½ 51	56¾	
	Aug. 8. 0 ^h 7' P.M. S. wind, and hazy weather above.	30.036 27.543	68 57	—118 —075	29.918 27.468	2226.3	{ —194.7 = 65.	68¾ 56	62¾	
	Aug. 8. 2 ^h 7' P.M. S. wind, weather something clearer.	30.027 27.533	69½ 58½	—122 —079	29.905 27.454	2228.3	{ —142.7 = 64.	69½ 57	63¼	
	Substituting Mr. DE LUC's equation for the air, 2231.1 60°.8—39°.7=21°.1×2.1									
	Aug. 7. 6 ^h 7' A.M.	30.154 26.462	56¾ 47½	—081 —045	30.073 26.417	3377.6	{ —177.4 = 52.5	56¾ 45½	50¾	
	Aug. 7. 9 ^h 7' A.M.	30.165 26.468	60 49¼	—092 —050	30.073 26.418	3376.6	{ —178.4 = 52.8	60 47¼	53¾	
	Aug. 7. 0 ^h 7' P.M.	30.140 26.488	61½ 60½	—097 —083	30.043 26.405	3363.4	{ —191.6 = 57.	61¾ 54	57¾	

of barometrical observations made on heights near Linhouse.

N° VI. of those near Carnarvon in North Wales.

N° V. near Linhouse.

Barometers.	Temperature of the quicksilver.	Equation for the heat of the quicksilver.	Equated heights of the barometers.	Logarithmic result in feet.	Logar. excess or defect in ft. and also in 1000th parts.	Temperature of the air,		Equation by the rule in 1000th parts, and also in feet.	Result by the rule,		Error of the rule in feet.	Ratio of the weight of quicksilver to air, being 1.
						Particular.	Mean.		Particular.	Mean.		
6 2	32° 30°	— +006	29.216 27.918	1184.2	{ +7.6 ft. = $\frac{64}{1000}$	32° 29	30° $\frac{1}{2}$	{ + $\frac{34}{1000}$ = 4. ft.	1180.	1181.3	+ 4.7	10894
1 2	32 27	— +015	28.941 27.647	1191.9	{ + 15.3 = 12.8	32 26	29	{ — 7. = 8.3	1182.6			
0 8	31 $\frac{1}{2}$ 24	+001 +025	28.991 27.713	1174.8	{ + 9.2 = 7.9	30 $\frac{1}{4}$ 22	26 $\frac{1}{8}$	{ — 14. = 16.4	1158.4	— —	— 7.2	10910
Equation for the air, — 39°.7—26°.1=13°.6×2.1								{ = 28.6 = 33.6	1141.2	— —	—24.4	
0 3	49 45	—055 —042	29.195 27.961	1125.3	{ — 53.2 = 47.3	48° 45	46° $\frac{1}{2}$	{ + 35. = 39.4	1164.7	— —	—13.7	11441
6 1	41 39	—029 —023	29.657 29.288	379.7	{ — 6.8 = 18.	40 39	39 $\frac{1}{2}$	{ + 18. = 6.8	386.5	— —	— —	10736
0 4	34 $\frac{3}{4}$ 32	—009 —	28.571 27.714	793.6	{ + 1.6 = 2.	34 $\frac{1}{4}$ 30	32 $\frac{1}{5}$	{ + 0.3 = 0.2	793.8	— —	+ 1.8	11077
4 0	32 25	— +022	28.574 27.732	779.4	{ + 2.8 = 3.6	31 23 $\frac{1}{2}$	27 $\frac{1}{4}$	{ — 10.2 = 9.3	770.1	— —	— 6.5	11068
2 2	35 33	—009 —003	27.983 27.579	379.	{ — 9.5 = 28.2	33 33	33	{ + 2.2 = 0.8	379.8	— —	— 8.7	11540

N° VI. near Carnarvon.

3 4	62 $\frac{1}{2}$ 54	—098 —066	29.595 27.148	2248.8	{ —122.2 + 54.4	62 $\frac{1}{2}$ 51	56 $\frac{3}{4}$	{ + 59.6 = 134.	2382.8	2391.8	+ 20.8	11594
6 3	68 57	—118 —075	29.918 27.468	2226.3	{ —194.7 = 65.	68 $\frac{3}{4}$ 56	62 $\frac{3}{8}$	{ + 75. = 167.	2393.3			
7 3	69 $\frac{1}{2}$ 58 $\frac{1}{4}$	—122 —079	29.905 27.454	2228.3	{ —142.7 = 64.	69 $\frac{1}{2}$ 57	63 $\frac{1}{4}$	{ + 76.8 = 171.	2399.3			
Equation for the air, 2231.1 60°.8—39°.7=21°.1×2.1								{ + 44.3 = 98.8	— —	2330.	—41.	
4 2	56 $\frac{3}{4}$ 47 $\frac{1}{2}$	—081 —045	30.073 26.417	3377.6	{ —177.4 = 52.5	56 $\frac{3}{8}$ 45 $\frac{1}{8}$	50 $\frac{3}{4}$	{ + 45. = 152.6	3530.2	3551.	— —	11646
5 8	60 49 $\frac{1}{4}$	—092 —050	30.073 26.418	3376.6	{ —178.4 = 52.8	60 47 $\frac{1}{4}$	53 $\frac{3}{4}$	{ + 52.5 = 177.4	3554.			
0 8	61 $\frac{1}{2}$ 60 $\frac{1}{2}$	—097 —083	30.043 26.405	3363.4	{ —191.6 = 57.	61 $\frac{3}{4}$ 54	57 $\frac{7}{8}$	{ + 61. = 205.	3568.4			

Cornhill, 1178.4 ft. } Linhouse, and Cor- } ston hill, 4 feet be- } low the top, 386.5 ft. }	1776, Dec. 16 ^h 11 ['] } A.M. high N. wind, } clear weather. }	28.580 } 27.714 }	34 $\frac{3}{4}$ } 32 }	—009 } —	28.571 } 27.714 }	793.6 }	{ + 1.6 } { = 2. }	34 $\frac{1}{4}$ } 30 }	32 $\frac{1}{5}$ }
Cornhill, and } East cairn hill, 776.6 } feet. }	Dec. 17. 1 ^h A.M. } light W. wind. }	28.574 } 27.710 }	32 } 25 }	— } +022 }	28.574 } 27.732 }	779.4 }	{ + 2.8 } { = 3.6 }	31 } 23 $\frac{1}{2}$ }	27 $\frac{1}{4}$ }
Linhouse, and Cor- } ston hill, 388.5 feet. }	Nov. 20. 1 ^h P.M. } snow had fallen, } high W. wind. }	27.992 } 27.582 }	35 } 33 }	—009 } —003 }	27.983 } 27.579 }	379. }	{ — 9.5 } { = 28.2 }	33 } 33 }	33 }

N° VI. near Carnarvon.

Carnarvon Quay, and Moel Eilio, 2371 feet.	1775, Aug. 4. 1 ^h 7' } P.M. rain above, } clear below. }	29.693 } 27.714 }	62 $\frac{1}{2}$ } 54 }	—098 } —066 }	29.595 } 27.148 }	2248.8 }	{ —122.2 } { + 54.4 }	62 $\frac{1}{2}$ } 51 }	56 $\frac{3}{4}$ }
	Aug. 8. 0 ^h 7' P.M. } S. wind, and hazy } weather above. }	30.036 } 27.543 }	68 } 57 }	—118 } —075 }	29.918 } 27.468 }	2226.3 }	{ —194.7 } { = 65. }	68 $\frac{3}{4}$ } 56 }	62 $\frac{3}{8}$ }
	Aug. 8. 2 ^h 7' P.M. } S. wind, weather } something clearer. }	30.027 } 27.533 }	69 $\frac{1}{2}$ } 58 $\frac{1}{4}$ }	—122 } —079 }	29.905 } 27.454 }	2228.3 }	{ —142.7 } { = 64. }	69 $\frac{1}{2}$ } 57 }	63 $\frac{1}{4}$ }
	Substituting Mr. DE LUC's equation for the air, 2231.1 60°.8—39°.7=21°.1×2.1								

Carnarvon Quay, and Peak of Snow- don, 3555 feet.	Aug. 7. 6 ^h 7' A.M.	{ 30.154 } 26.462 }	56 $\frac{3}{4}$ } 47 $\frac{1}{2}$ }	—081 } —045 }	30.073 } 26.417 }	3377.6 }	{ —177.4 } { = 52.5 }	56 $\frac{3}{8}$ } 45 $\frac{1}{8}$ }	50 $\frac{3}{4}$ }
	Aug. 7. 9 ^h 7' A.M.	{ 30.165 } 26.468 }	60 } 49 $\frac{1}{4}$ }	—092 } —050 }	30.073 } 26.418 }	3376.6 }	{ —178.4 } { = 52.8 }	60 } 47 $\frac{1}{4}$ }	53 $\frac{3}{4}$ }
	Aug. 7. 0 ^h 7' P.M.	{ 30.140 } 26.488 }	61 $\frac{1}{2}$ } 60 $\frac{1}{2}$ }	—097 } —083 }	30.043 } 26.405 }	3363.4 }	{ —191.6 } { = 57. }	61 $\frac{3}{4}$ } 54 }	57 $\frac{7}{8}$ }
	Aug. 7. 2 ^h 7' P.M.	{ 30.144 } 26.478 }	62 } 53 $\frac{3}{4}$ }	—099 } —063 }	30.045 } 26.415 }	3355.3 }	{ —199.7 } { = 59.5 }	62 } 51 }	56 $\frac{1}{2}$ }
	Aug. 14. 8 ^h 7' A.M. fog above.	{ 29.984 } 26.271 }	56 $\frac{1}{2}$ } 42 $\frac{3}{4}$ }	—080 } —031 }	29.904 } 26.240 }	3405.9 }	{ —149.1 } { = 43.8 }	55 $\frac{1}{4}$ } 43 }	49 $\frac{1}{8}$ }
	Aug. 14. 9 ^h 7' fog and rain.	{ 29.978 } 26.279 }	58 $\frac{1}{2}$ } 44 }	—087 } —035 }	29.891 } 26.244 }	3390.6 }	{ —164.4 } { = 48.5 }	57 $\frac{3}{4}$ } 43 $\frac{1}{2}$ }	50 $\frac{3}{4}$ }
	Aug. 14. 10 ^h 7'.	{ 29.972 } 26.280 }	60 } 44 $\frac{1}{2}$ }	—091 } —036 }	29.881 } 26.244 }	3381.9 }	{ —173.1 } { = 51.2 }	60 } 44 $\frac{3}{4}$ }	52 $\frac{1}{4}$ }
	Aug. 14. 11 ^h 7'.	{ 29.974 } 26.280 }	61 $\frac{1}{2}$ } 44 $\frac{3}{4}$ }	—097 } —037 }	29.877 } 26.243 }	3379.4 }	{ —175.6 } { = 52. }	61 } 45 }	53 }
Aug. 14. 0 ^h 7',	{ 29.976 } 26.282 }	62 $\frac{1}{2}$ } 46 $\frac{1}{2}$ }	—100 } —042 }	29.876 } 26.240 }	3381.5 }	{ —173.5 } { = 51.3 }	62 } 46 }	54 }	
Barometrical height of Snowdon from the mean of two days observations,						3379.1	{ —175.9 } { = 52.1 }	— } — }	53.1

Mr. DE LUC's equation for the air, — —

$$53°.1-39°.7=13°.4 \times 2.1=28.14$$

6	41	—029	29.657	} 379.7	{ — 6.8 = 18.	40	} 39 $\frac{1}{2}$	{ + 18. = 6.8	} 386.5	— — — —	10736
1	39	—023	29.288								
0	34 $\frac{3}{4}$	—009	28.571	} 793.6	{ + 1.6 = 2.	34 $\frac{1}{4}$	} 32 $\frac{1}{5}$	{ + 0.3 = 0.2	} 793.8	— — + 1.8	11077
4	32	—	27.714								
4	32	—	28.574	} 779.4	{ + 2.8 = 3.6	31	} 27 $\frac{1}{4}$	{ — 10.2 = 9.3	} 770.1	— — — 6.5	11068
0	25	+022	27.732								
2	35	—009	27.983	} 379.	{ — 9.5 = 28.2	33	} 33	{ + 2.2 = 0.8	} 379.8	— — — 8.7	11540
2	33	—003	27.579								

N° VI. near Carnarvon.

3	62½	—098	29.595	} 2248.8	{ —122.2 + 54.4	62½	} 56¾	{ + 59.6 =134.	} 2382.8	— — — —	11594
4	54	—066	27.148								
6	68	—118	29.918	} 2226.3	{ —194.7 = 65.	68¾	} 62⅜	{ + 75. =167.	} 2393.3	} 2391.8 + 20.8	
3	57	—075	27.468								
7	69½	—122	29.905	} 2228.3	{ —142.7 = 64.	69½	} 63¼	{ + 76.8 =171.	} 2399.3	— — — —	11566
3	58¼	—079	27.454								
Equation for the air, 2231.1 60°.8—39°.7=21°.1 × 2.1									{ + 44.3 = 98.8	— — 2330.	—41.
4	56¾	—081	30.073	} 3377.6	{ —177.4 = 52.5	56⅜	} 50¾	{ + 45. =152.6	} 3530.2	— — — —	11646
2	47½	—045	26.417								
5	60	—092	30.073	} 3376.6	{ —178.4 = 52.8	60	} 53¾	{ + 52.5 =177.4	} 3554.	} 3551.	
8	49¼	—050	26.418								
0	61½	—097	30.043	} 3363.4	{ —191.6 = 57.	61¾	} 57⅞	{ + 61. =205.	} 3568.4	— — — —	11704
8	60½	—083	26.405								
4	62	—099	30.045	} 3355.3	{ —199.7 = 59.5	62	} 56½	{ + 58.5 =196.	} 3551.3	— — — —	11643
8	53¾	—063	26.415								
4	56½	—080	29.904	} 3405.9	{ —149.1 = 43.8	55¼	} 49⅛	{ + 40. =136.2	} 3542.1	— — — —	11643
1	42¾	—031	26.240								
8	58½	—087	29.891	} 3390.6	{ —164.4 = 48.5	57¾	} 50¼	{ + 44.3 =150.4	} 3541.	— — — —	11643
9	44	—035	26.244								
2	60	—091	29.881	} 3381.9	{ —173.1 = 51.2	60	} 52¼	{ + 48. =162.7	} 3544.6	} 3546.8	
30	44½	—036	26.244								
74	61½	—097	29.877	} 3379.4	{ —175.6 = 52.	61	} 53	{ + 50. =169.	} 3548.4	— — — —	11704
30	44¾	—037	26.243								
76	62½	—100	29.876	} 3381.5	{ —173.5 = 51.3	62	} 54	{ + 52.3 =176.2	} 3557.7	— — — —	11704
82	46½	—042	26.240								
Reduction from the mean of					} 3379.1	{ —175.9 = 52.1	—	} 53.1	{ =176.3	— — 3548.9	—6.1
— — 53°.1—39°.7=13°.4 × 2.1=28.14									= 95.1	— — 3474.2	—80.8

Compu-

Computations of part of Mr. DE LUC's barometrical observations, answering to
of the air.

Stations with their geometrical heights in feet.		Date of the observations.	Observed heights of the inferior and superior barometers.	Temperature of the quicksilver.	Equation for the heat of the quicksilver.	Equated heights of the barometers.	Logarithmic result in feet.	Logar. excess or defect in ft. and also in 1000 parts.	Temperature of the air,		
									Particular.	Mean	Reduced.
Coldest of the Sun-rising Observations.	1ft. 230.5	1760, Feb. 9. 8 ^h 30' A.M.	28.986 28.703	33 ⁰³ / ₄ 26 ¹⁴ / ₄	—006 +018	28.980 28.721	233.9	{ + 3.4 ft. = ^{14.5} / ₁₀₀₀	24 ¹⁰ / ₄ 26 ¹⁴ / ₄	25 ⁰¹ / ₄	—
		March 9. 6 ^h A.M.	28.875 28.586	37 ¹² / ₂ 28 ¹⁴ / ₄	—018 +012	28.857 28.598	234.9	{ + 4.4 = 18.7	27 ¹² / ₂ 32	29 ³ / ₄	—
	2d. 457.	March 9. 6 ^h 8' A.M.	28.875 28.342	37 ¹² / ₂ 30	—018 +006	28.857 28.348	463.7	{ + 6.6 = 14.5	27 ¹² / ₂ 31 ¹² / ₂	29 ¹ / ₂	—
	3d. 624.5	March 9. 6 ^h 15' A.M.	28.875 28.170	37 ¹² / ₂ 32	—018 —	28.857 28.170	627.8	{ + 4.3 = 7.	27 ¹⁴ / ₄ 34	30 ⁵ / ₈	—
	4th. 776.7	March 9. 6 ^h 30' A.M.	28.875 28.009	37 ¹² / ₂ 32	—018 —	28.857 28.009	777.2	{ + 0.5 = 0.7	27 ¹⁴ / ₄ 32 ¹² / ₂	30	—
Coldest of the ordinary observations.	5th. 977.2	March 9. 6 ^h 45' A.M.	28.875 27.798	37 ¹² / ₂ 33 ³ / ₄	—018 —005	28.857 27.793	978.9	{ + 1.7 = 1.7	27 ¹⁴ / ₄ 32	29 ³ / ₄	—
	2d, 457.	Feb. 9. 9 ^h A.M.	28.997 28.470	32 28 ¹⁴ / ₄	— +012	28.997 28.482	466.9	{ + 9.8 = 21.	25 ¹⁴ / ₄ 29	27 ¹ / ₈	26
	3d, 624.5	Feb. 9. 9 ^h 15' A.M.	28.997 28.298	32 30	— +006	28.997 28.304	630.3	{ + 5.8 = 9.2	28 30	29	28
	4th. 776.7	Feb. 9. 9 ^h 30' A.M.	28.997 28.142	32 32	— —	— —	780.2	{ + 3.6 = 4.5	40 ¹ / ₂ 32	36 ¹ / ₄	30
	5th. 977.2	Feb. 9. 10 ^h A.M.	28.997 27.931	33 ³ / ₄ 35 ¹ / ₂	—006 —011	28.991 27.920	980.8	{ + 3.6 = 3.5	40 ³ / ₄ 37	38 ² / ₈	31
	6th. 1298.9	Feb. 9. 10 ^h 15' A.M.	29.002 27.604	32 37 ¹² / ₂	— —017	29.002 27.587	1303.4	{ + 4.5 = 3.5	41 36 ³ / ₄	38 ⁷ / ₈	31
	7th. 1513.3	Feb. 9. 10 ^h 30' A.M.	29.008 27.393	33 ³ / ₄ 41	—006 —027	29.002 27.366	1513.	{ — 0.3 = 0.2	41 37 ³ / ₄	39 ¹ / ₈	33
	8th. 1938.9	Feb. 9. 11 ^h A.M.	29.002 26.955	35 ¹² / ₂ 39 ¹⁴ / ₄	—011 —021	28.991 26.934	1917.7	{ — 21.2 = 11.0	43 ¹² / ₂ 37 ³ / ₄	40 ⁵ / ₈	34
	9th. 2094.5	Feb. 9. 11 ^h 15' A.M.	28.997 26.771	35 ¹² / ₂ 39 ¹⁴ / ₄	—011 —021	28.986 26.750	2091.8	{ — 2.7 = 1.5	43 ³ / ₄ 39 ³ / ₄	41 ³ / ₄	35
	10th. 2356.3	Feb. 9. 11 ^h 45' A.M.	28.992 26.494	35 ¹² / ₂ 39 ¹⁴ / ₄	—011 —021	28.981 26.473	2358.6	{ + 2.3 = 1.	44 ³ / ₄ 38 ³ / ₄	41 ³ / ₄	35
	11th. 2486.3	Feb. 9. noon.	28.986 26.366	33 ³ / ₄ 37 ¹² / ₂	—006 —016	28.980 26.350	2479.	{ — 7.3 = 3.0	44 ³ / ₄ 36	40 ³ / ₈	34
		14th. 2922.	1759, July 15, 4 ^h P.M.	28.759 25.950	74 ¹² / ₂ 71	—131 —105	28.628 25.845	2664.8	{ — 257.9 = 96.7	88 ¹² / ₂ 74	81

c's barometrical observations, answering to the coldest and hottest temperatures of the air.

Equation for the heat of the quick-silver.	Equated heights of the barometers.	Logarithmic result in feet.	Logar. excess or defect in ft. and also in 1000th parts.	Temperature of the air,			Equation by the rule in 1000th parts, and also in feet.	Result by the rule,		Error of the rule in feet.	Ratio of the weight of quick-silver to air, being 1.
				Particular.	Mean.	Reduced.		Particular.	Mean.		
$\frac{3}{4} \frac{1}{4}$ -006 +018	28.980 28.721	} 233.9	{ + 3.4 ft. = $\frac{14.5}{1000}$	$24\frac{1}{4}^{\circ}$ $26\frac{1}{4}$	$25^{\circ} \frac{1}{4}$	—	{ — $\frac{15.4}{1000}$ = 3.6 ft. }	229.9	{ — — 231.8	— — + 1.3	10598
$\frac{1}{2} \frac{1}{4}$ -018 +012	28.857 28.598	} 234.9	{ + 4.4 = 18.7	$27\frac{1}{2}$ 32	$29\frac{3}{4}$	—	{ — 4.9 = 1.2 }	233.7	{ — — — —	— — — —	10598
$\frac{1}{2}$ -018 +006	28.857 28.348	} 463.7	{ + 6.6 = 14.5	$27\frac{1}{2}$ $31\frac{1}{2}$	$29\frac{1}{2}$	—	{ — 5.6 = 2.6 }	461.1	— —	+ 4.1	10732
$\frac{1}{2}$ -018 —	28.857 28.170	} 627.8	{ + 4.3 = 7.	$27\frac{1}{4}$ 34	$30^{\circ} \frac{5}{8}$	—	{ — 3.5 = 2.3 }	625.5	— —	+ 1.	10876
$\frac{1}{2}$ -018 —	28.857 28.009	} 777.2	{ + 0.5 = 0.7	$27\frac{1}{4}$ $32\frac{1}{2}$	30°	—	{ — 4.4 = 3.4 }	773.8	— —	— 2.9	10978
$\frac{1}{2} \frac{3}{4}$ -018 -005	28.857 27.793	} 978.9	{ + 1.7 = 1.7	$27\frac{1}{4}$ 32	$29\frac{3}{4}$	—	{ — 5. = 4.9 }	974.0	— —	— 3.2	11000
$\frac{1}{4}$ +012	28.997 28.482	} 466.9	{ + 9.8 = 21.	$25\frac{1}{4}$ 29	$27^{\circ} \frac{1}{8}$	26°	{ — 14. = 6.5 }	460.4	— —	+ 3.4	10649
+006	28.997 28.304	} 630.3	{ + 5.8 = 9.2	28 30	29	28	{ — 9. = 5.7 }	624.6	— —	— —	10814
—	—	} 780.2	{ + 3.6 = 4.5	$40\frac{1}{2}$ 32	$36\frac{1}{4}$	$30\frac{1}{2}$	{ — 3.5 = 2.7 }	777.5	— —	— —	10901
$\frac{3}{4} \frac{1}{2}$ -006 -011	28.991 27.920	} 980.8	{ + 3.6 = 3.5	$40\frac{3}{4}$ 37	$38\frac{7}{8}$	$31\frac{1}{2}$	{ — 1.1 = 1.1 }	979.7	— —	+ 2.5	10949
$\frac{1}{2}$ -017	29.002 27.587	} 1303.4	{ + 4.5 = 3.5	41 $36\frac{3}{4}$	$38\frac{7}{8}$	$31\frac{1}{2}$	{ — 1.1 = 1.4 }	1302.	— —	+ 3.1	11024
$\frac{3}{4}$ -006 -027	29.002 27.366	} 1513.	{ — 0.3 = 0.2	41 $37\frac{3}{4}$	$39\frac{1}{8}$	$33\frac{1}{2}$	{ + 3.3 = 5. }	1518.	— —	+ 4.7	11120
$\frac{1}{2} \frac{1}{4}$ -011 -021	28.991 26.934	} 1917.7	{ — 21.2 = 11.0	$43\frac{1}{2}$ $37\frac{3}{4}$	$40^{\circ} \frac{5}{8}$	$34\frac{1}{2}$	{ + 6. = 11.5 }	1929.2	— —	+ 9.7	11306
$\frac{1}{2} \frac{3}{4}$ -011 -021	28.986 26.750	} 2091.8	{ — 2.7 = 1.5	$43\frac{3}{4}$ $39\frac{3}{4}$	$41\frac{3}{4}$	35	{ + 6.6 = 12.6 }	2104.4	— —	+ 9.9	11241
$\frac{1}{2} \frac{1}{4}$ -011 -021	28.981 26.473	} 2358.6	{ + 2.3 = 1.	$44\frac{3}{4}$ $38\frac{3}{4}$	$41\frac{3}{4}$	35	{ + 6.6 = 15.6 }	2374.2	— —	+ 17.9	11274
$\frac{3}{4} \frac{1}{2}$ -006 -016	28.980 26.350	} 2479.	{ — 7.3 = 3.0	$44\frac{3}{4}$ 36	$40^{\circ} \frac{3}{8}$	$34\frac{1}{2}$	{ + 5.6 = 14. }	2493.	— —	+ 6.7	11357
$\frac{1}{2}$ -131 -105	28.628 25.845	} 2664.8	{ — 257.9 = 96.7	$88\frac{1}{2}$ 74	81	$75\frac{1}{2}$	{ + 101. = 269.2 }	2934.	— —	+ 12.	12541

Coldest of the ordinary observations.

Hottest of the ordinary observations on the highest stations.

3d. 624.5	{	Feb. 9. 9 ^h 15' { A.M.	{ 28.997 28.298	32 30	— +006	28.997 28.304	{	630.3	{	+ 5.8 = 9.2	28 30	29	28
4th. 776.7	{	Feb. 9. 9 ^h 30' { A.M.	{ 28.997 28.142	32 32	— —	— —	{	780.2	{	+ 3.6 = 4.5	40 ¹ / ₂ 32	36 ¹ / ₄	30
5th. 977.2	{	Feb. 9. 10 ^h { A.M.	{ 28.997 27.931	33 ³ / ₄ 35 ¹ / ₂	—006 —011	28.991 27.920	{	980.8	{	+ 3.6 = 3.5	40 ³ / ₄ 37	38 ² / ₈	31
6th. 1298.9	{	Feb. 9. 10 ^h 15' { A.M.	{ 29.002 27.604	32 37 ¹ / ₂	— —017	29.002 27.587	{	1303.4	{	+ 4.5 = 3.5	41 30 ³ / ₄	38 ² / ₈	31
7th. 1513.3	{	Feb. 9. 10 ^h 30' { A.M.	{ 29.008 27.393	33 ³ / ₄ 41	—006 —027	29.002 27.366	{	1513.	{	— 0.3 = 0.2	41 37 ³ / ₄	39 ¹ / ₈	33
8th. 1938.9	{	Feb. 9. 11 ^h { A.M.	{ 29.002 26.955	35 ¹ / ₂ 39 ³ / ₄	—011 —021	28.991 26.934	{	1917.7	{	— 21.2 = 11.0	43 ¹ / ₂ 37 ³ / ₄	40 ⁵ / ₈	34
9th. 2094.5	{	Feb. 9. 11 ^h 15' { A.M.	{ 28.997 26.771	35 ¹ / ₂ 39 ³ / ₄	—011 —021	28.986 26.750	{	2091.8	{	— 2.7 = 1.5	43 ³ / ₄ 39 ³ / ₄	41 ³ / ₄	35
10th. 2356.3	{	Feb. 9. 11 ^h 45' { A.M.	{ 28.992 26.494	35 ¹ / ₂ 39 ³ / ₄	—011 —021	28.981 26.473	{	2358.6	{	+ 2.3 = 1.	44 ³ / ₄ 38 ³ / ₄	41 ³ / ₄	35
11th. 2486.3	{	Feb. 9. noon. {	{ 28.986 26.366	33 ³ / ₄ 37 ¹ / ₂	—006 —016	28.980 26.350	{	2479.	{	— 7.3 = 3.0	44 ³ / ₄ 36	40 ³ / ₈	34
14th. 2922.	{	1759, July 15, 4 ^h P.M.	{ 28.759 25.950	74 ¹ / ₂ 71	—131 —105	28.628 25.845	{	2664.8	{	—257.9 = 96.7	88 ¹ / ₂ 74	81	75
15th. 3119.2	{	July 15. 2 ^h P.M. {	{ 28.797 25.778	74 ¹ / ₂ 71	—131 —108	28.666 25.670	{	2876.5	{	—242.7 = 84.5	85 68 ³ / ₄	76 ³ / ₄	73
	{	July 15. 3 ^h 30' { P.M.	{ 28.764 25.778	74 ¹ / ₂ 68 ³ / ₄	—131 —103	28.633 25.675	{	2841.4	{	—277.8 = 97.7	90 ¹ / ₂ 74	82	76
10th. 2356.3	{	1760, July 20. 10 ^h 15' A.M. {	{ 28.775 26.499	71 72 ³ / ₄	—121 —117	28.654 26.382	{	2152.6	{	—203.7 = 94.7	87 ¹ / ₄ 74	80 ⁵ / ₈	75
	{	July 20. 3 ^h 15' { P.M.	{ 28.731 26.460	74 ¹ / ₂ 72 ³ / ₄	—131 —118	28.600 26.342	{	2143.	{	—213.3 = 99.5	91 ¹ / ₂ 75 ³ / ₄	83 ⁵ / ₈	77
11th. 2486.3	{	July 20. 10 ^h 45' { A.M.	{ 28.769 26.366	71 68 ³ / ₄	—121 —104	28.648 26.262	{	2266.	{	—221.3 = 97.7	87 ¹ / ₂ 74 ¹ / ₂	81	75
	{	July 20. 3 ^h { P.M.	{ 28.726 26.327	76 ¹ / ₂ 72 ³ / ₄	—138 —116	28.588 26.211	{	2262.	{	—224.3 = 99.	92 ¹ / ₄ 76 ¹ / ₂	84 ¹ / ₄	77
12th. 2752.	{	July 20. 11 ^h 30' { A.M.	{ 28.758 26.100	72 ³ / ₄ 68 ³ / ₄	—126 —103	28.632 25.997	{	2516.3	{	—235.7 = 94.	88 72 ¹ / ₂	80 ¹ / ₄	74
	{	July 20. 2 ^h 30' { P.M.	{ 28.720 26.066	76 ¹ / ₂ 71	—138 —110	28.582 25.956	{	2511.2	{	—240.8 = 95.7	92 77	84 ¹ / ₄	77
13th. 2877.5	{	July 20. noon. {	{ 28.747 25.977	72 ³ / ₄ 68 ³ / ₄	—126 —103	28.621 25.874	{	2629.3	{	—248.2 = 94.7	89 73 ¹ / ₂	81 ¹ / ₄	75
	{	July 20. 1 ^h 45' { P.M.	{ 28.720 25.691	74 ¹ / ₂ 68 ³ / ₄	—131 —105	28.859 25.856	{	2618.2	{	—259.3 = 99.	92 ³ / ₄ 75	83 ² / ₈	77

Mean of the hottest,

95.7
1000

81.7

75

—	28.997	630.3	{ + 5.8	28	{ — 9.	624.6	—	—	—	10814
+006	28.304		{ = 9.2	30	{ = 5.7					
—	—	780.2	{ + 3.6	40 $\frac{1}{2}$	{ — 3.5	777.5	—	—	—	10901
—	—		{ = 4.5	32	{ = 2.7					
—006	28.991	980.8	{ + 3.6	40 $\frac{3}{4}$	{ — 1.1	979.7	—	—	+ 2.5	10949
—011	27.920		{ = 3.5	37	{ = 1.1					
—	29.002	1303.4	{ + 4.5	41	{ — 1.1	1302.	—	—	+ 3.1	11024
—017	27.587		{ = 3.5	36 $\frac{3}{4}$	{ = 1.4					
—006	29.002	1513.	{ — 0.3	41	{ + 3.3	1518.	—	—	+ 4.7	11120
—027	27.366		{ = 0.2	37 $\frac{3}{4}$	{ = 5.					
—011	28.991	1917.7	{ — 21.2	43 $\frac{1}{2}$	{ + 6.	1929.2	—	—	+ 9.7	11306
—021	26.934		{ = 11.0	37 $\frac{3}{4}$	{ = 11.5					
—011	28.986	2091.8	{ — 2.7	43 $\frac{3}{4}$	{ + 6.6	2104.4	—	—	+ 9.9	11241
—021	26.750		{ = 1.5	39 $\frac{3}{4}$	{ = 12.6					
—011	28.981	2358.6	{ + 2.3	44 $\frac{3}{4}$	{ + 6.6	2374.2	—	—	+ 17.9	11274
—021	26.473		{ = 1.	38 $\frac{3}{4}$	{ = 15.6					
—006	28.980	2479.	{ — 7.3	44 $\frac{3}{4}$	{ + 5.6	2493.	—	—	+ 6.7	11357
—016	26.350		{ = 3.0	36	{ = 14.					
—131	28.628	2664.8	{ — 257.9	88 $\frac{1}{2}$	{ + 101.	2934.	—	—	+ 12.	12541
—105	25.845		{ = 96.7	74	{ = 269.2					
—131	28.666	2876.5	{ — 242.7	85	{ + 96.5	3177.3	{	—	—	12439
—108	25.670		{ = 84.5	68 $\frac{3}{4}$	{ = 300.8			—	—	
—131	28.633	2841.4	{ — 277.8	90 $\frac{1}{2}$	{ + 102.	3131.6	{	3154.4	+ 35.2	
—103	25.675		{ = 97.7	74	{ = 290.2			—	—	12603
—121	28.654	2152.6	{ — 203.7	87 $\frac{1}{4}$	{ + 102.	2372.2	{	—	—	
—117	26.382		{ = 94.7	74	{ = 219.6			—	—	
—131	28.600	2143.	{ — 213.3	91 $\frac{1}{2}$	{ + 106.	2370.2	{	2571.2	+ 14.9	12429
—118	26.342		{ = 99.5	75 $\frac{1}{4}$	{ = 227.2			—	—	
—121	28.648	2266.	{ — 221.3	87 $\frac{1}{2}$	{ + 101.8	2496.7	{	—	—	
—104	26.262		{ = 97.7	74 $\frac{1}{2}$	{ = 230.7			—	—	
—138	28.588	2262.	{ — 224.3	92 $\frac{1}{4}$	{ + 106.	2501.7	{	2499.2	+ 12.9	12468
—116	26.211		{ = 99.	76 $\frac{1}{2}$	{ = 239.7			—	—	
—126	28.632	2516.3	{ — 235.7	88	{ + 97.6	2761.9	{	—	—	
—103	25.997		{ = 94.	72 $\frac{1}{2}$	{ = 245.6			—	—	
—138	28.582	2511.2	{ — 240.8	92	{ + 106.	2777.4	{	2769.6	+ 17.6	12504
—110	25.956		{ = 95.7	77	{ = 266.2			—	—	
—126	28.621	2629.3	{ — 248.2	89	{ + 101.8	2897.1	{	—	—	
—103	25.874		{ = 94.7	73 $\frac{1}{2}$	{ = 267.6			—	—	
—131	28.859	2618.2	{ — 259.3	92 $\frac{3}{4}$	{ + 106.	2895.7	{	2896.4	+ 18.9	12548
—105	25.856		{ = 99.	75	{ = 277.5			—	—	
Mean of the hottest,			95.7	81.7	75.6					
			1000							

Compu-

Continuation of Mr. DE LUC's barometrical observations.

Stations with their geometrical heights in feet.	Date of the observations.	Observed heights of the inferior and superior barometers.	Temperature of the quicksilver.	Equation for the heat of the quicksilver.	Equated heights of the barometers.	Logarithmic result in feet.	Logar excess or defect in ft. and also in 1000th parts.	Temperature of the air,		
								Particular.	Mean.	Reduced.
The Dole, by Sir GEORGE SHUCK-BURGH's measurement, is above the lake of Geneva 293 ft. Mr. DE LUC's lowermost barometer was higher than the lake 83 ft. hence the vertical distance of the barometers, 4210 feet.	1764, July 29. 1 ^h P.M.	$\left. \begin{array}{l} 28.953 \\ 24.951 \end{array} \right\}$	$\left. \begin{array}{l} 78^{\circ \frac{1}{4}} \\ 67 \end{array} \right\}$	$\left. \begin{array}{l} -145 \\ -095 \end{array} \right\}$	$\left. \begin{array}{l} 28.808 \\ 24.856 \end{array} \right\}$	$\left. \begin{array}{l} 3845. \\ \end{array} \right\}$	$\left. \begin{array}{l} \{-365 \text{ ft.} \\ = \frac{949}{1000} \end{array} \right\}$	$\left. \begin{array}{l} 77^{\circ \frac{3}{4}} \\ 64^{\circ \frac{1}{2}} \end{array} \right\}$	$71^{\circ \frac{3}{4}}$	70°
	July 29. 1 ^h 30' P.M.	$\left. \begin{array}{l} 28.942 \\ 24.940 \end{array} \right\}$	$\left. \begin{array}{l} 78^{\circ \frac{1}{4}} \\ 65^{\circ \frac{1}{4}} \end{array} \right\}$	$\left. \begin{array}{l} -145 \\ -090 \end{array} \right\}$	$\left. \begin{array}{l} 28.797 \\ 24.850 \end{array} \right\}$	$\left. \begin{array}{l} 3841. \\ \end{array} \right\}$	$\left. \begin{array}{l} \{-369. \\ = 96. \end{array} \right\}$	$\left. \begin{array}{l} 78^{\circ \frac{1}{4}} \\ 65 \end{array} \right\}$	$71^{\circ \frac{1}{2}}$	70°
	1765, July 21. 10 ^h 30' A.M.	$\left. \begin{array}{l} 28.698 \\ 24.640 \end{array} \right\}$	$\left. \begin{array}{l} 67 \\ 59^{\circ \frac{3}{4}} \end{array} \right\}$	$\left. \begin{array}{l} -108 \\ -075 \end{array} \right\}$	$\left. \begin{array}{l} 28.590 \\ 24.565 \end{array} \right\}$	$\left. \begin{array}{l} 3954. \\ \end{array} \right\}$	$\left. \begin{array}{l} \{-256. \\ = 64.7 \end{array} \right\}$	$\left. \begin{array}{l} 67^{\circ \frac{1}{2}} \\ 51 \end{array} \right\}$	$59^{\circ \frac{1}{4}}$	58°
	1764, July 8. 8 ^h A.M.	$\left. \begin{array}{l} 28.692 \\ 24.636 \end{array} \right\}$	$\left. \begin{array}{l} 71 \\ 57^{\circ \frac{3}{4}} \end{array} \right\}$	$\left. \begin{array}{l} -121 \\ -070 \end{array} \right\}$	$\left. \begin{array}{l} 28.571 \\ 24.566 \end{array} \right\}$	$\left. \begin{array}{l} 3935. \\ \end{array} \right\}$	$\left. \begin{array}{l} \{-275. \\ = 70. \end{array} \right\}$	$\left. \begin{array}{l} 73 \\ 56 \end{array} \right\}$	$64^{\circ \frac{1}{2}}$	63°
	1757, June 2. 6 ^h A.M.	$\left. \begin{array}{l} 30.077 \\ 29.817 \end{array} \right\}$	$\left. \begin{array}{l} 76 \\ 76 \end{array} \right\}$	$\left. \begin{array}{l} -142 \\ -141 \end{array} \right\}$	$\left. \begin{array}{l} 29.935 \\ 29.686 \end{array} \right\}$	$\left. \begin{array}{l} 217.7 \\ \end{array} \right\}$	$\left. \begin{array}{l} \{-20. \\ = 92. \end{array} \right\}$	$\left. \begin{array}{l} - \\ - \end{array} \right\}$	$75^{\circ \frac{3}{4}}$	73°
	June 2. 4 ^h $\frac{1}{2}$ P.M.	$\left. \begin{array}{l} 30.088 \\ 29.846 \end{array} \right\}$	$\left. \begin{array}{l} 82^{\circ \frac{1}{2}} \\ 84^{\circ \frac{1}{2}} \end{array} \right\}$	$\left. \begin{array}{l} -163 \\ -169 \end{array} \right\}$	$\left. \begin{array}{l} 29.925 \\ 29.677 \end{array} \right\}$	$\left. \begin{array}{l} 216.8 \\ \end{array} \right\}$	$\left. \begin{array}{l} \{-21. \\ = 96. \end{array} \right\}$	$\left. \begin{array}{l} - \\ - \end{array} \right\}$	82	79°
Light-house of Genoa, 237.6 ft	June 23. 9 ^h $\frac{1}{2}$ A.M.	$\left. \begin{array}{l} 30.116 \\ 29.857 \end{array} \right\}$	$\left. \begin{array}{l} 79 \\ 75 \end{array} \right\}$	$\left. \begin{array}{l} -152 \\ -138 \end{array} \right\}$	$\left. \begin{array}{l} 29.964 \\ 29.719 \end{array} \right\}$	$\left. \begin{array}{l} 214.8 \\ \end{array} \right\}$	$\left. \begin{array}{l} \{-22.8 \\ = 107. \end{array} \right\}$	$\left. \begin{array}{l} - \\ - \end{array} \right\}$	79	76°
	June 23. 5 ^h 45' P.M.	$\left. \begin{array}{l} 30.041 \\ 29.796 \end{array} \right\}$	$\left. \begin{array}{l} 79 \\ 79 \end{array} \right\}$	$\left. \begin{array}{l} -152 \\ -150 \end{array} \right\}$	$\left. \begin{array}{l} 29.889 \\ 29.646 \end{array} \right\}$	$\left. \begin{array}{l} 212.7 \\ \end{array} \right\}$	$\left. \begin{array}{l} \{-24.9 \\ = 117. \end{array} \right\}$	$\left. \begin{array}{l} - \\ - \end{array} \right\}$	78	75°
	July 26. 1 ^h P.M.	$\left. \begin{array}{l} 30.021 \\ 29.774 \end{array} \right\}$	$\left. \begin{array}{l} 83^{\circ \frac{3}{4}} \\ 83^{\circ \frac{3}{4}} \end{array} \right\}$	$\left. \begin{array}{l} -166 \\ -164 \end{array} \right\}$	$\left. \begin{array}{l} 29.855 \\ 29.610 \end{array} \right\}$	$\left. \begin{array}{l} 214.7 \\ \end{array} \right\}$	$\left. \begin{array}{l} \{-22.9 \\ = 107. \end{array} \right\}$	$\left. \begin{array}{l} - \\ - \end{array} \right\}$	81	77°
For the barometrical height of Turin above Genoa,		$\left. \begin{array}{l} 30.019 \\ +.071 \\ 30.090 \end{array} \right\}$	$\left. \begin{array}{l} 77 \\ 77 \end{array} \right\}$	$\left. \begin{array}{l} -146 \\ -141 \end{array} \right\}$	$\left. \begin{array}{l} 29.944 \\ 29.125 \end{array} \right\}$	$\left. \begin{array}{l} 722.6 \\ \end{array} \right\}$	$\left. \begin{array}{l} \{- \\ - \end{array} \right\}$	$\left. \begin{array}{l} - \\ - \end{array} \right\}$	77	$-$
		$\left. \begin{array}{l} 29.197 \\ +.069 \\ 29.266 \end{array} \right\}$	$\left. \begin{array}{l} 77 \\ 77 \end{array} \right\}$	$\left. \begin{array}{l} -146 \\ -141 \end{array} \right\}$	$\left. \begin{array}{l} 29.944 \\ 29.125 \end{array} \right\}$	$\left. \begin{array}{l} 722.6 \\ \end{array} \right\}$	$\left. \begin{array}{l} \{- \\ - \end{array} \right\}$	$\left. \begin{array}{l} - \\ - \end{array} \right\}$	77	$-$
		$\left. \begin{array}{l} 29.319 \\ 28.831 \end{array} \right\}$	$\left. \begin{array}{l} 72^{\circ \frac{3}{4}} \\ 72^{\circ \frac{3}{4}} \end{array} \right\}$	$\left. \begin{array}{l} -129 \\ -126 \end{array} \right\}$	$\left. \begin{array}{l} 29.190 \\ 28.705 \end{array} \right\}$	$\left. \begin{array}{l} 436.6 \\ \end{array} \right\}$	$\left. \begin{array}{l} \{- \\ - \end{array} \right\}$	$\left. \begin{array}{l} - \\ - \end{array} \right\}$	$72^{\circ \frac{3}{4}}$	$-$
		$\left. \begin{array}{l} 29.319 \\ 28.831 \end{array} \right\}$	$\left. \begin{array}{l} 72^{\circ \frac{3}{4}} \\ 72^{\circ \frac{3}{4}} \end{array} \right\}$	$\left. \begin{array}{l} -129 \\ -126 \end{array} \right\}$	$\left. \begin{array}{l} 29.190 \\ 28.705 \end{array} \right\}$	$\left. \begin{array}{l} 436.6 \\ \end{array} \right\}$	$\left. \begin{array}{l} \{- \\ - \end{array} \right\}$	$\left. \begin{array}{l} - \\ - \end{array} \right\}$	$72^{\circ \frac{3}{4}}$	$-$

Mr. DE LUC's room above Genoa, —
 Surface of the Lake of Geneva in summer below Mr. DE LUC's room, —

Surface of the Lake of Geneva above the Mediterranean, —

By Mr. DE LUC's rule the Lake is elevated above the Sea 1126 French, —

In the observations on the Dole, if Mr. DE LUC's equation for the air is substituted instead of that resulting from the British observations, the barometrical height will be, } 3894 66°.6—

uation of Mr. DE LUC's barometrical observations.

Equation for the heat of the quick-silver.	Equated heights of the barometers.	Logarithmic result in feet.	Logar excess or defect in ft. and also in 1000th parts.	Temperature of the air,			Equation by the rule in 1000th parts, and also in feet.	Result by the rule,		Error of the rule in feet.	Ratio of the weight of quick-silver to air, being 1.
				Particular.	Mean.	Reduced.		Particular.	Mean.		
$\frac{1}{4}$ —145 —095	28.808 24.856	} 3845.	{ —365 ft. = $\frac{94.9}{1000}$	77 $\frac{3}{4}$ 64 $\frac{1}{2}$	71 $\frac{1}{4}$	70 $^{\circ}$	{ + $\frac{88.2}{1000}$ = 339.8 f.	4184.8	}	— —	12714
$\frac{1}{4}$ —145 —090	28.797 24.850			78 $\frac{1}{4}$ 65	71 $\frac{1}{2}$	70	{ + 88.2 = 338.8	4179.8			
$\frac{3}{4}$ —108 —075	28.590 24.565	} 3954.	{ —256. = 64.7	67 $\frac{1}{2}$ 51	59 $\frac{1}{4}$	58	{ + 60. = 237.	4191.	}	— —	12520
$\frac{3}{4}$ —121 —070	28.571 24.566			73 56	64 $\frac{1}{2}$	63	{ + 72.4 = 285.	4220.			
										Mean	12595
—142 —141	29.935 29.686	} 217.7	{ — 20. = 92.	—	75 $\frac{3}{4}$	73	{ + 103. = 22.4	240.1	}	— —	+ 0.6 12672
$\frac{1}{2}$ —163 —169	29.925 29.677			—	82	79	{ + 108. = 23.4	240.2			
—152 —138	29.964 29.719	} 214.8	{ — 22.8 = 107.	—	79	76	{ + 104. = 22.3	237.1	}	238.2	
—152 —150	29.889 29.646			—	78	75	{ + 106.5 = 22.6	235.3			
$\frac{3}{4}$ —166 —164	29.855 29.610	} 214.7	{ — 22.9 = 107.	—	81	77	{ + 111. = 23.8	238.5	}		
				Mean	76						
7 —146	29.944	} 722.6	{ —	—	77	—	{ + 111.5 = 80.6	803.2	}		
7 —141	29.125			—		—					
$\frac{3}{4}$ —129 —126	29.190 28.705	} 436.6	{ —	—	72 $\frac{3}{4}$	—	{ + 99. = 43.2	479.8	}		

DE LUC's room above Genoa, — 1283.
 ce of the Lake of Geneva in summer below Mr. DE LUC's room, 53.3
 ce of the Lake of Geneva above the Mediterranean, — 1229.7

uc's rule the Lake is elevated above the Sea 1126 French, or 1200 English feet.

's equation for the air is substituted instead } 3894 66°.6—39°.7=26°.9×2.1 { + 56.5 } Error.
 s, the barometrical height will be, } = 220. } = 4114.—96.0

Light-house of Genoa, 237.6 ft	P.M.	{	29.840	84 $\frac{1}{2}$	-109	29.877	{	-90.	-	{			{
	June 23. 9 $\frac{1}{2}$ A.M.	{	30.116	79	-152	29.964	{	-22.8	-	{	79	76	{
		{	29.857	75	-138	29.719	{	=107.	-	{			{
	P.M.	{	30.041	79	-152	29.889	{	-24.9	-	{	78	75	{
	June 23. 5 $\frac{1}{2}$ P.M.	{	29.796	79	-130	29.646	{	=117.	-	{			{
		{					{			{			{
	P.M.	{	30.021	83 $\frac{3}{4}$	-166	29.855	{	-22.9	-	{	81	77	{
	July 26. 1 $\frac{1}{2}$ P.M.	{	29.774	83 $\frac{3}{4}$	-164	29.610	{	=107.	-	{			{
		{					{			{			{
										Mean	76		
For the barometrical height of Turin above Genoa,		{	30.019				{			{			{
		{	+ .071				{			{			{
		{	30.090	77	-146	29.944	{			{	77	-	{
		{	29.197				{			{			{
		{	+ .069	77	-141	29.125	{			{			{
For the barometrical height of Mr. DE LUC's room above Turin,		{	29.319	72 $\frac{3}{4}$	-129	29.190	{			{	72 $\frac{3}{4}$	-	{
		{	28.831	72 $\frac{3}{4}$	-126	28.705	{			{			{

—109	29.877	} 214.8	{ — 90. = 107.	—	} 79	76	{ + 104. = 22.3	} 237.1	} 238.2 + 0.6	12672
—152	29.964									
—138	29.719	} 212.7	{ — 24.9 = 117.	—	} 78	75	{ + 106.5 = 22.6	} 235.3		
—152	29.889									
—150	29.646	} 214.7	{ — 22.9 = 107.	—	} 81	77	{ + 111. = 23.8	} 238.5		
—166	29.855									
—164	29.610	Mean	76	—	} 77	—	{ + 111.5 = 80.6	} 803.2		
—146	29.944									
—141	29.125	} 436.6	{ — — = —	—	} 72 ³ / ₄	—	{ + 99. = 43.2	} 479.8		
—129	29.190									
—126	28.705	Mean	76	—	} 77	—	{ + 111.5 = 80.6	} 803.2		
—146	29.944									

DE LUC's room above Genoa, — — 1283.
 ce of the Lake of Geneva in summer below Mr. DE LUC's room, 53.3
 ce of the Lake of Geneva above the Mediterranean, — 1229.7

uc's rule the Lake is elevated above the Sea 1126 French, or 1200 English feet.

's equation for the air is substituted instead } 3894 66°.6—39°.7=26°.9×2.1 { + 56.5 } Error.
 s, the barometrical height will be, } =220. } =4114.—96.0

ometrical Observations, Sept. 22, 1751, at the Cape of Good Hope.

66°	—111	29.890	} 3192.	{ —211. = 66.	66°	} 58	—	{ + 62.4 = 199.2	} 3391.2	— — — 11.8	11713
52°	—058	26.444									
66°	—111	29.866	} 3289.	{ —179. = 544.	66°	} 58	—	{ + 62.4 = 205.2	} 3494.2	— — + 40.2	11662
50°	—053	26.324									
Mean											11687
$2.7 = 18^{\circ}.3 \times 2.1 \left\{ \begin{array}{l} + 38.4 \\ = 124.4 \end{array} \right\} 3364.4$											
											—62.6

Computations of barometrical observations made on heights that have not
geometrically.

Date.	Stations of the barometers.	Observed heights of the inferior and superior barometers.	Temperature of the quicksilver.	Equation for the heat of the quicksilver.	Equated heights of the barometers.	Logarithmic result in feet.	Temperature of the air,	
							Particular.	Mean.
1773, July 8.	{ Level of the sea at Inver-gourie, and Belmont-castle.	29.932	54°	—072	29.860	{ 181.3	{ 54°	54° {
		29.734	57	—081	29.653		{ 54	{
		29.988	65	—108	29.880		{ 63	60 {
		28.974	62	—095	28.879		{ 57	{
1776, Sept. 12.	{ Ditto.	30.331	56½	—080	30.251	{ 908.9	{ 57½	53¾ {
		29.275	51	—061	29.214		{ 50	{
Sept. 11.	{ Castle Menzies.	29.756	60¼	—092	29.64	{ 82.7	{ 61	62 {
		29.674	64½	—104	29.570		{ 63	{
Sept. 17.	{ Top of Farragan.	29.794	63¾	—102	29.692	{ 2205.8	{ 65	57½ {
		27.344	52½	—062	27.282		{ 50	{
Sept. 12.	{ Top of Ben Lawers.	29.800	55	—075	29.725	{ 3677.	{ 54	45 {
		25.830	38	—017	25.813		{ 36	{
Sept. 13.	{ Top of Ben More.	30.000	55½	—077	29.923	{ 3542.9	{ 52½	44¾ {
		26.148	42	—029	26.119		{ 37	{
Sept. 12.	{ Top of Ben Gloc.	29.712	62	—097	29.615	{ 3291.3	{ 62	53½ {
		26.142	48	—041	26.101		{ 45	{
Sept. 13.	{ Blair of Athol-lawn.	29.636	60	—091	29.545	{ 219.6	{ 58	59¼ {
		29.380	58	—083	29.297		{ 60½	{
Aug. 22.	{ Top of King's Seat.	29.904	68	—116	29.788	{ 985.	{ 67	65½ {
		28.791	66½	—108	28.683		{ 64	{
1775, Sept. 5.	{ Hill of Barry.	29.870	62	—098	29.772	{ 444.	{ 60	58 {
		29.345	56	—076	29.269		{ 56	{
Sept. 5.	{ Dunfinane-hill,	29.784	62	—097	29.687	{ 766.	{ 62	60½ {
		28.913	59	—086	28.827		{ 59	{
1774, Aug. 29 and 30. mean of three observations.	{ Quay at the new bridge of Glasgow, and station at Lanark.	29.560	55¾	—077	29.483	{ 625.2	{ 53¾	52¼ {
		28.850	52¾	—066	28.784		{ 50¾	{
1772, Aug. 6. 2 ^h P.M.	{ Freeport in the island of Ila, 19 feet above the sea, and summit of the South-pap of Jura,	30.224	67	—114	30.110	{ 2300.2	{ 60	58½ {
		27.642	57	—076	27.566		{ 57	{
1772, Sept. 25. 9 ^h 25' A.M.	{ Hafniford in Iceland, at the sea-shore, and summit of Mount Hecla.	29.859	49	—056	29.803	{ 4886.8	{ 43	33½ {
		24.722	38	—016	24.706		{ 24	{

barometrical observations made on heights that have not been determined geometrically.

Stations of the barometers.	Observed heights of the inferior and superior barometers.	Temperature of the quicksilver.	Equation for the heat of the quicksilver.	Equated heights of the barometers.	Logarithmic result in feet.	Temperature of the air,		Equation for the heat of the air in 1000 parts, and in feet.	Vertical distance of the barometers.	Horizontal distance of the barometer in miles.
						Particular.	Mean.			
Level of the sea at Inver-gourie, and Belmont-castle.	29.932 29.734	54° 57	—072 —081	29.860 29.653	181.3	{ 54° 54 }	54°	{ + $\frac{54.2}{1000}$ =9.8 f. }	191.1	10 $\frac{1}{4}$
Superior barometer, Top of Kinpurney-hill.	29.988 28.974	65 62	—108 —095	29.880 28.879	887.9	{ 63 57 }	60	{ +71. =63.1 }	951. 955.3	2 $\frac{3}{8}$
Ditto.	30.331 29.275	56 $\frac{1}{4}$ 51	—080 —061	30.251 29.214	908.9	{ 57 $\frac{1}{2}$ 50 }	53 $\frac{3}{4}$	{ +56. =50.8 }	959.7	2 $\frac{5}{8}$
Castle Menzies.	29.756 29.674	60 $\frac{1}{4}$ 64 $\frac{1}{2}$	—092 —104	29.64 29.570	82.7	{ 61 63 }	62	{ +74. =6.1 }	88.8	28 $\frac{1}{2}$
Top of Farragan.	29.794 27.344	63 $\frac{3}{4}$ 52 $\frac{1}{2}$	—102 —062	29.692 27.282	2205.8	{ 65 50 }	57 $\frac{1}{2}$	{ +62.4 =137.8 }	2343.6	29
Top of Ben Lawers.	29.800 25.830	55 38	—075 —017	29.725 25.813	3677.	{ 54 36 }	45	{ +30. =110. }	3787.	42
Top of Ben More.	30.000 26.148	55 $\frac{1}{2}$ 42	—077 —029	29.923 26.119	3542.9	{ 52 $\frac{1}{2}$ 37 }	44 $\frac{3}{4}$	{ +31. =109.8 }	3652.7	53 $\frac{1}{2}$
Top of Ben Glœ.	29.712 26.142	62 48	—097 —041	29.615 26.101	3291.3	{ 62 45 }	53 $\frac{1}{2}$	{ +51. =167.9 }	3459.2	27 $\frac{1}{4}$
Blair of Athol-lawn.	29.636 29.380	60 58	—091 —083	29.545 29.297	219.6	{ 58 60 $\frac{1}{2}$ }	59 $\frac{1}{4}$	{ +67. =14.7 }	234.3	30
Top of King's Seat.	29.904 28.791	68 66 $\frac{1}{2}$	—116 —108	29.788 28.683	985.	{ 67 64 }	65 $\frac{1}{2}$	{ +84.3 =83. }	1068.	6 $\frac{3}{4}$
Hill of Barry.	29.870 29.345	62 56	—098 —076	29.772 29.269	444.	{ 60 56 }	58	{ +64. =28.4 }	472.4	4 $\frac{1}{2}$
Dunfinane-hill,	29.784 28.913	62 59	—097 —086	29.687 28.827	766.	{ 62 59 }	60 $\frac{1}{2}$	{ +71.5 =54.8 }	820.8	7 $\frac{1}{2}$
Way at the new bridge of Glasgow, and station at Lanark.	29.560 28.850	55 $\frac{3}{4}$ 52 $\frac{3}{4}$	—077 —066	29.483 28.784	625.2	{ 53 $\frac{3}{4}$ 50 $\frac{3}{4}$ }	52 $\frac{1}{4}$	{ +50.0 =31.3 }	656.5	22 $\frac{1}{2}$
Deepport in the island of Jura, 19 feet above the sea, and summit of the south-pap of Jura,	30.224 27.642	67 57	—114 —076	30.110 27.566	2300.2	{ 60 57 }	58 $\frac{1}{2}$	{ +66.3 =152.5 }	2452.7	4 $\frac{1}{4}$
Snafniford in Iceland, at the sea shore, and summit of Mount Hecla.	29.859 24.722	49 38	—056 —016	29.803 24.706	4886.8	{ 43 24 }	33 $\frac{1}{2}$	{ +34 =16.6 }	4903.4	76

Date.	Stations of the barometers.	Observed heights of the inferior and superior barometers.	Temperature of the quicksilver.	Equation for the heat of the quicksilver.	Equated heights of the barometers.	Logarithmic result in feet.	Temperature of the air,	
							Particular.	Mean.
1773, July 8.	{ Level of the sea at Inver-gourie, and Belmont-castle.	{ 29.932	{ 54°	{ —072	{ 29.860	{ 181.3	{ 54°	{ 54°
		{ 29.734	{ 57	{ —081	{ 29.653	{ }	{ 54	{ }
1776, Sept. 12.	{ Superior barometer, Top of Kinpurney-hill.	{ 29.988	{ 65	{ —108	{ 29.880	{ 887.9	{ 63	{ 60
		{ 28.974	{ 62	{ —095	{ 28.879	{ }	{ 57	{ }
1776, Sept. 12.	{ Ditto.	{ 30.331	{ 56½	{ —080	{ 30.251	{ 908.9	{ 57½	{ 53¾
		{ 29.275	{ 51	{ —061	{ 29.214	{ }	{ 50	{ }
Sept. 11.	{ Castle Menzies.	{ 29.756	{ 60¼	{ —092	{ 29.64	{ 82.7	{ 61	{ 62
		{ 29.074	{ 64½	{ —104	{ 29.570	{ }	{ 63	{ }
Sept. 17.	{ Top of Farragan.	{ 29.794	{ 63¾	{ —102	{ 29.692	{ 2205.8	{ 65	{ 57½
		{ 27.344	{ 52½	{ —062	{ 27.282	{ }	{ 50	{ }
Sept. 12.	{ Top of Ben Lawers.	{ 29.800	{ 55	{ —075	{ 29.725	{ 3677.	{ 54	{ 45
		{ 25.830	{ 38	{ —017	{ 25.813	{ }	{ 36	{ }
Sept. 12.	{ Top of Ben More.	{ 30.000	{ 55½	{ —077	{ 29.923	{ 3542.9	{ 52½	{ 44¾
		{ 26.148	{ 42	{ —029	{ 26.119	{ }	{ 37	{ }
Sept. 13.	{ Top of Ben Gloe.	{ 29.712	{ 62	{ —097	{ 29.615	{ 3291.3	{ 62	{ 53½
		{ 26.142	{ 48	{ —041	{ 26.101	{ }	{ 45	{ }
Aug. 22.	{ Blair of Athol-lawn.	{ 29.636	{ 60	{ —091	{ 29.545	{ 219.6	{ 58	{ 59½
		{ 29.380	{ 58	{ —083	{ 29.297	{ }	{ 60½	{ }
1775, Sept. 5.	{ Top of King's Seat.	{ 29.904	{ 68	{ —116	{ 29.788	{ 985.	{ 67	{ 65½
		{ 28.791	{ 66½	{ —108	{ 28.683	{ }	{ 64	{ }
Sept. 5.	{ Hill of Barry.	{ 29.870	{ 62	{ —098	{ 29.772	{ 444.	{ 60	{ 58
		{ 29.345	{ 56	{ —076	{ 29.269	{ }	{ 56	{ }
1774, Aug. 29 and 30. mean of three observations.	{ Dunfinane-hill,	{ 29.784	{ 62	{ —097	{ 29.687	{ 766.	{ 62	{ 60½
		{ 28.913	{ 59	{ —086	{ 28.827	{ }	{ 59	{ }
1772, Aug. 6. 2 ^h P.M.	{ Quay at the new bridge of Glasgow, and station at Lanark.	{ 29.560	{ 55¾	{ —077	{ 29.483	{ 625.2	{ 53¾	{ 52¾
		{ 28.850	{ 52¾	{ —066	{ 28.784	{ }	{ 50¾	{ }
1772, Sept. 25. 9 ^h 25' A.M.	{ Freeport in the island of Ila, 19 feet above the sea, and summit of the South-pap of Jura,	{ 30.224	{ 67	{ —114	{ 30.110	{ 2300.2	{ 60	{ 58½
		{ 27.642	{ 57	{ —076	{ 27.566	{ }	{ 57	{ }
1772, Sept. 25. 9 ^h 25' A.M.	{ Hafniford in Iceland, at the sea-shore, and summit of Mount Hecla.	{ 29.859	{ 49	{ —056	{ 29.803	{ 4886.8	{ 43	{ 33½
		{ 24.722	{ 38	{ —016	{ 24.706	{ }	{ 24	{ }

Stations of the barometers.	Observed heights of the inferior and superior barometers.	Temperature of the quicksilver.	Equation for the heat of the quicksilver.	Equated heights of the barometers.	Logarithmic result in feet.	Temperature of the air,		Equation for the heat of the air in 1000 parts, and in feet.	Vertical distance of the barometers.	Horizontal distance of the barometer in miles.
						Particular.	Mean.			
Level of the sea at Inver-gourie, and Belmont-castle.	29.932 29.734	54° 57	—072 —081	29.860 29.653	181.3	{ 54° 54 }	54° {	+ $\frac{54.2}{1000}$ =9.8 f.	191.1	10 $\frac{1}{4}$
Superior barometer, Top of Kinpurney-hill.	29.988 28.974	65 62	—108 —095	29.880 28.879	887.9	{ 63 57 }	60 {	+71. =63.1	951.	2 $\frac{5}{8}$
Ditto.	30.331 29.275	56 $\frac{1}{4}$ 51	—080 —061	30.251 29.214	908.9	{ 57 $\frac{1}{2}$ 50 }	53 $\frac{3}{4}$ {	+56. =50.8	955.3 959.7	2 $\frac{5}{8}$
Castle Menzies.	29.756 29.674	60 $\frac{1}{4}$ 64 $\frac{1}{2}$	—092 —104	29.64 29.570	82.7	{ 61 63 }	62 {	+74. =6.1	88.8	28 $\frac{1}{2}$
Top of Farragan.	29.794 27.344	63 $\frac{3}{4}$ 52 $\frac{1}{2}$	—102 —062	29.692 27.282	2205.8	{ 65 50 }	57 $\frac{1}{2}$ {	+62.4 =137.8	2343.6	29
Top of Ben Lawers.	29.800 25.830	55 38	—075 —017	29.725 25.813	3677.	{ 54 36 }	45 {	+30. =110.	3787.	42
Top of Ben More.	30.000 26.148	55 $\frac{1}{2}$ 42	—077 —029	29.923 26.119	3542.9	{ 52 $\frac{1}{2}$ 37 }	44 $\frac{3}{4}$ {	+31. =109.8	3652.7	53 $\frac{1}{2}$
Top of Ben Glloe.	29.712 26.142	62 48	—097 —041	29.615 26.101	3291.3	{ 62 45 }	53 $\frac{1}{2}$ {	+51. =167.9	3459.2	27 $\frac{1}{4}$
Blair of Athol-lawn.	29.636 29.380	60 58	—091 —083	29.545 29.297	219.6	{ 58 60 $\frac{1}{2}$ }	59 $\frac{1}{4}$ {	+67. =14.7	234.3	30
Top of King's Seat.	29.904 28.791	68 66 $\frac{1}{2}$	—116 —108	29.788 28.683	985.	{ 67 64 }	65 $\frac{1}{2}$ {	+84.3 =83.	1068.	6 $\frac{3}{4}$
Hill of Barry.	29.870 29.345	62 56	—098 —076	29.772 29.269	444.	{ 60 56 }	58 {	+64. =28.4	472.4	4 $\frac{1}{2}$
Dunfinane-hill,	29.784 28.913	62 59	—097 —086	29.687 28.827	766.	{ 62 59 }	60 $\frac{1}{2}$ {	+71.5 =54.8	820.8	7 $\frac{1}{2}$
Quay at the new bridge of Glasgow, and station at Lanark.	29.560 28.850	55 $\frac{3}{4}$ 52 $\frac{3}{4}$	—077 —066	29.483 28.784	625.2	{ 53 $\frac{3}{4}$ 50 $\frac{3}{4}$ }	52 $\frac{1}{4}$ {	+50.0 =31.3	656.5	22 $\frac{1}{2}$
Deepport in the island of Jura, 19 feet above the sea, and summit of the south-pap of Jura,	30.224 27.642	67 57	—114 —076	30.110 27.566	2300.2	{ 60 57 }	58 $\frac{1}{2}$ {	+66.3 =152.5	2452.7	4 $\frac{1}{4}$
Snafniford in Iceland, at the sea shore, and summit of Mount Hecla.	29.859 24.722	49 38	—056 —016	29.803 24.706	4886.8	{ 43 24 }	33 $\frac{1}{2}$ {	+34 =16.6	4903.4	76

Computations of Mr. BOUGUER's observations in Peru, supposing them to have the mean temperature of the day, between the coldest of the morn

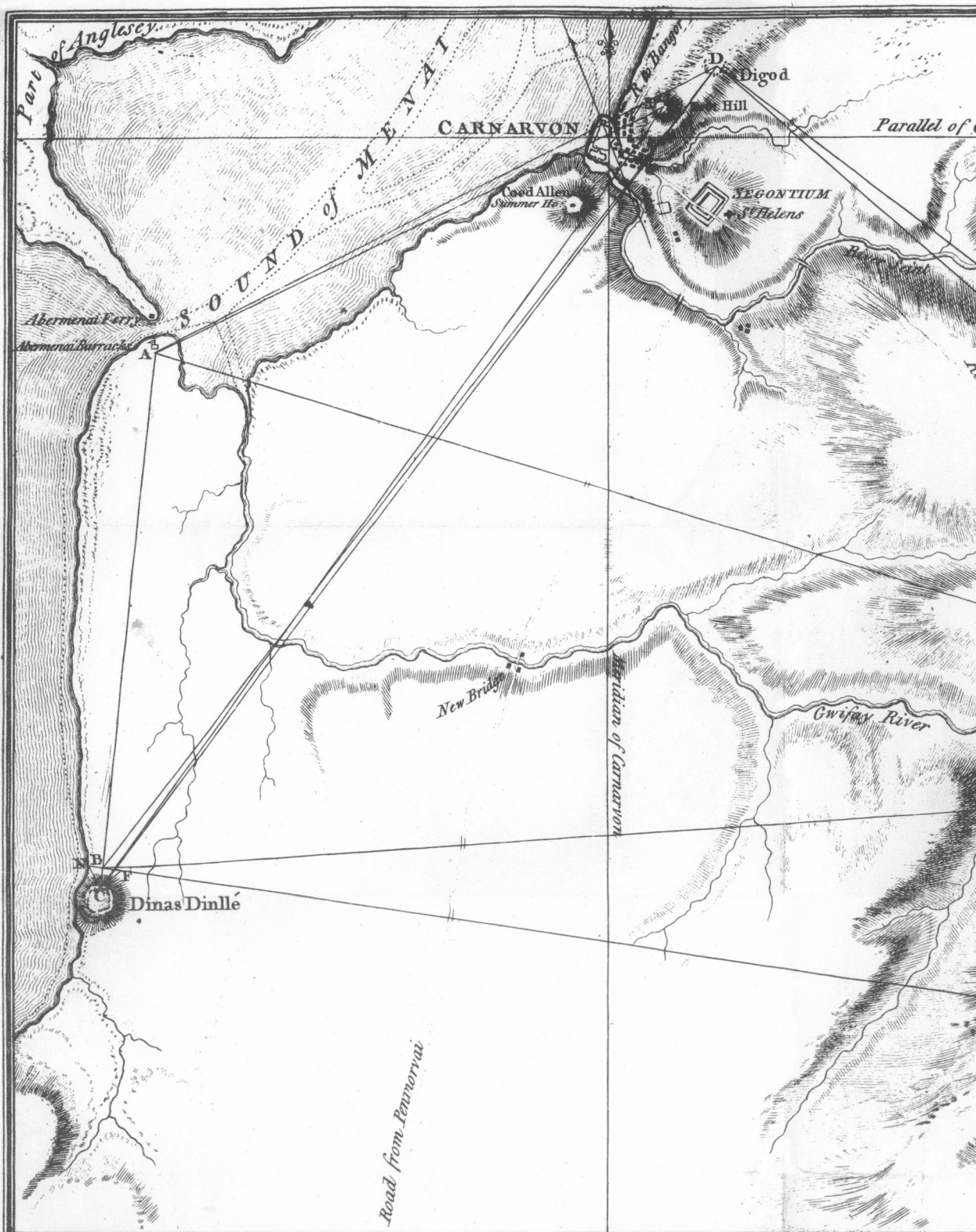
Relative heights of the stations, with respect to the South-sea,		Stations of the barometers, with their geometrical distance in feet.	Observed heights of the inferior and superior barometers.	Temperature of the quicksilver.	Equation for the heat of the quicksilver.	Equated heights of the barometers.	Mean heights of the barometers.	Logarithmic result in feet.
Heights of the columns of air, whose bases stood at the sea,	{	15833 { South-sea, Coraçon,	29.930 16.808	84 $\frac{1}{2}$ ⁰ 43 $\frac{1}{2}$	—169 —022	29.761 16.786	{ 23.27	14922.
		15564 { South-sea, Pichincha,	— 16.963	84 $\frac{1}{2}$ 44 $\frac{1}{2}$	— —024	29.761 16.939		
		9374 { South-sea, Quito,	— 21.403	84 $\frac{1}{2}$ 65 $\frac{1}{2}$	—078 —	29.761 21.325		
		7840 { South-sea, Carabourou,	— 22.625	84 $\frac{1}{2}$ 66 $\frac{1}{2}$	—084 —	29.761 22.541		
	{	Coraçon, 15833 } 7993 { Carabourou, Coraçon,	— —	66 $\frac{1}{2}$ 43 $\frac{1}{2}$	— —	22.541 16.786	{ 19.66	7681.6
		Pichincha, 15564 } 7724 { Carabourou, Pichincha,	— —	66 $\frac{1}{2}$ 44 $\frac{1}{2}$	— —	22.541 16.939		
		Coraçon, 15833 } 6459 { Quito, Coraçon,	— —	65 $\frac{1}{2}$ 43 $\frac{1}{2}$	— —	21.325 16.786		
		Pichincha, 15564 } 6190 { Quito, Pichincha, Mean of the four superior columns,	— — —	65 $\frac{1}{2}$ 44 $\frac{1}{2}$ —	— — —	21.325 16.939 —		
	{	Quito, 9374 } 1534 { Carabourou, Quito,	— —	66 $\frac{1}{2}$ 65 $\frac{1}{2}$	— —	22.541 21.325	{ 21.93	1445.
		Carabourou, 7840 }	—	—	—	—		
Superior sections of the columns of air, with the distances of their bases from the sea,								



Peru, supposing them to have been made at corresponding times, and in the
 ween the coldest of the morning and hottest of the afternoon.

the quicksilver.	Equation for the heat of the quick-silver.	Equated heights of the barome-ters.	Mean heights of the barometers.	Logarithmic result in feet.	Logar. excess or defect in ft. and also in 1000th parts.	Mean tempe-rature of the air.	Equation for the heat of the air in 1000th parts, and in feet.	Result by the rule in feet.	Error of the rule.	Ratio of the weight of quick-silver to air,	
										Particular	Mean.
$\frac{1}{2}$ $3\frac{1}{2}$	—169 —022	29.761 16.786	23.27	14922.	$\left\{ \begin{array}{l} -911 \text{ ft.} \\ = \frac{61.6}{1000} \end{array} \right\}$	64°	$\left\{ \begin{array}{l} + \frac{61.6}{1000} \\ =919. \text{ ft.} \end{array} \right\}$	15841.	+ 8.0	14590	14553
$4\frac{1}{2}$ $4\frac{1}{2}$	— —024	29.761 16.939								23.35	
$4\frac{1}{2}$ $5\frac{1}{2}$	—078 —	29.761 21.325	25.54	8685.5	$\left\{ \begin{array}{l} -688.5 \\ = 80. \end{array} \right\}$	75	$\left\{ \begin{array}{l} + 90. \\ =781.7 \end{array} \right\}$	9467.2	+93.2		13273
$4\frac{1}{2}$ $6\frac{1}{2}$	—084 —	29.761 22.541								26.15	7240.5
$5\frac{1}{2}$ $3\frac{1}{2}$	— —	22.541 16.786	19.66	7681.6	$\left\{ \begin{array}{l} -311.4 \\ = 40.5 \end{array} \right\}$	55	$\left\{ \begin{array}{l} + 35.2 \\ =274.4 \end{array} \right\}$	7952.	—41.		
$6\frac{1}{2}$ $4\frac{1}{2}$	— —	22.541 16.939								19.74	7445.1
$\frac{1}{2}$ $\frac{1}{2}$	— —	21.325 16.786	19.05	6236.5	$\left\{ \begin{array}{l} -222.5 \\ = 35.7 \end{array} \right\}$	$54\frac{1}{2}$	$\left\{ \begin{array}{l} + 33.2 \\ =207. \end{array} \right\}$	6443.5	—15.5		
$\frac{1}{2}$ $\frac{1}{2}$	— —	21.325 16.939								19.13	6000.1
— —	— —	— —	— —	— —	$\frac{36.3}{1000}$	55	— —	— —	— —		
$\frac{1}{2}$ $\frac{1}{2}$	— —	22.541 21.325	21.93	1445.	$\left\{ \begin{array}{l} - 89. \\ = 61.6 \end{array} \right\}$	66	$\left\{ \begin{array}{l} + 61. \\ = 88. \end{array} \right\}$	1533.	— 1.	15089	





GEO

The Base AB, situated on a perfectly level Plain, was measured twice in contrary directions, between the Barracks of Abermenai and the bottom of Dinas Dinlle, an ancient British Fortification, on the Sea Shore. The length of the Iron Chain made use of on this occasion, was ascertained by means of accurate Deal Rods, applied to it every Morning & Evening.

Triangles.		Angles		Sides
CBF and CBN				Feet.
for the prolongation of the Base B C, and distance	Obs ^d	CBF	84. 20. 40	B C.....482.2
	Hence	BCF	42. 55. 25	
		BFC	52. 53. 55	
	Obs ^d	NBC	98. 46. 50	N C.....612.2
		BCN	30. 8. 20	
				NC.....612.2

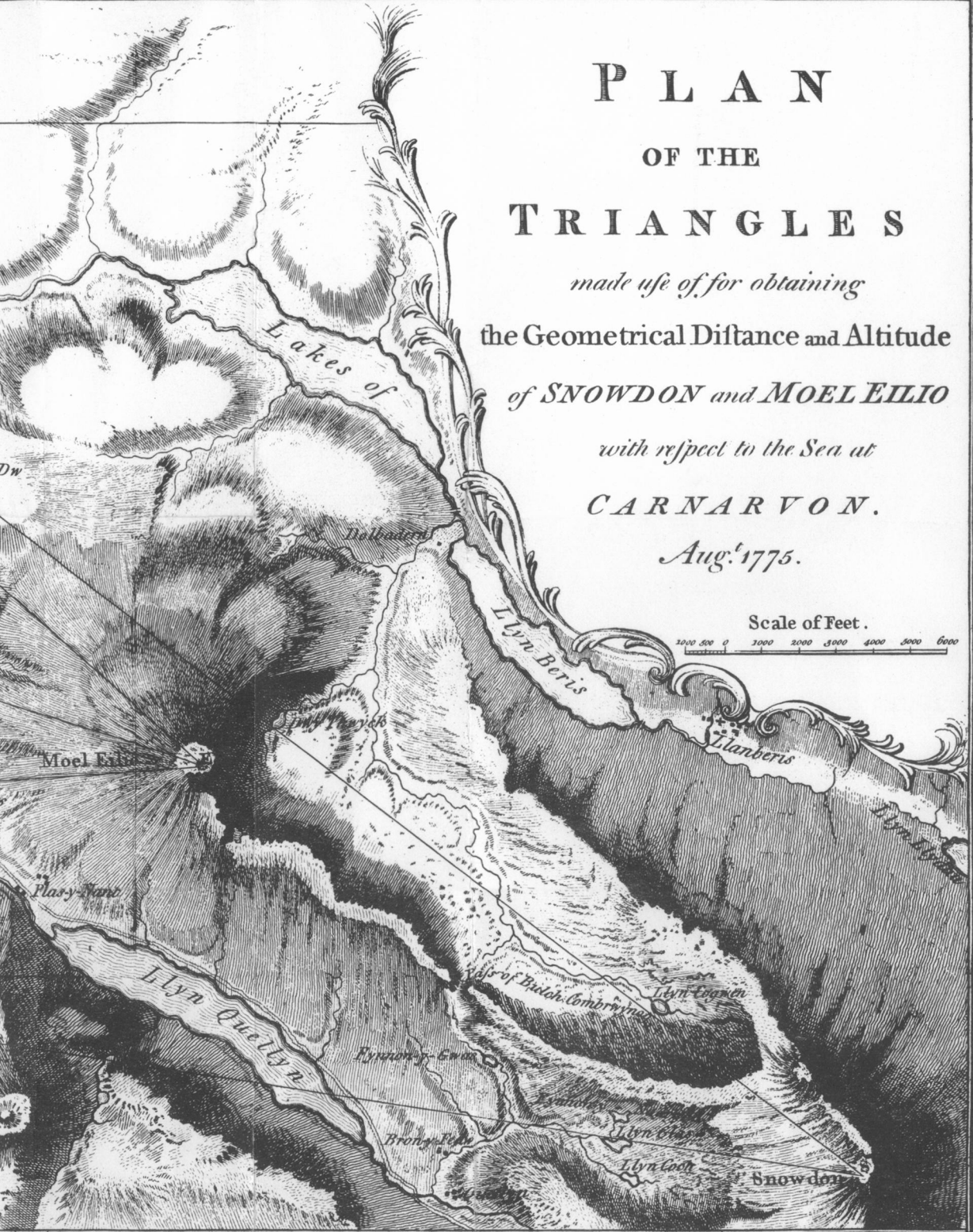


GEOMETRICAL OPERATIONS.

Angles.	Angles	Sides	Triangles	Angles	Sides	Relative Heights
and CBN prolong- of the Base d distance	$\begin{matrix} \text{Obf.}^d & \text{CBF} & 84.10.40 \\ & \text{BCF} & 42.55.25 \\ \text{Hence} & \text{BFC} & 52.53.55 \\ \text{Obs.}^d & \text{NBC} & 98.46.50 \\ & \text{BCN} & 30.8.20 \end{matrix}$	$\begin{matrix} \text{Feet.} \\ \text{BC} \dots 482.2 \\ \text{NC} \dots 612.5 \end{matrix}$	DEB and DAE, For the distance of	$\begin{matrix} \text{Obf.}^d & \text{EBA} & 79.49.10 \\ & \text{ABD} & 31.24.36 \\ = & \text{DBE} & 48.24.34 \\ \text{Obs.}^d & \text{EDC} & 86.27.5 \\ & \text{CDB} & 0.30.56 \end{matrix}$	$\begin{matrix} \text{Feet.} \\ \text{DE} \dots 29319.6 \end{matrix}$	S above B Trig Curvature & H Height of the S above B C above B Trig
						For the

PLAN
OF THE
TRIANGLES

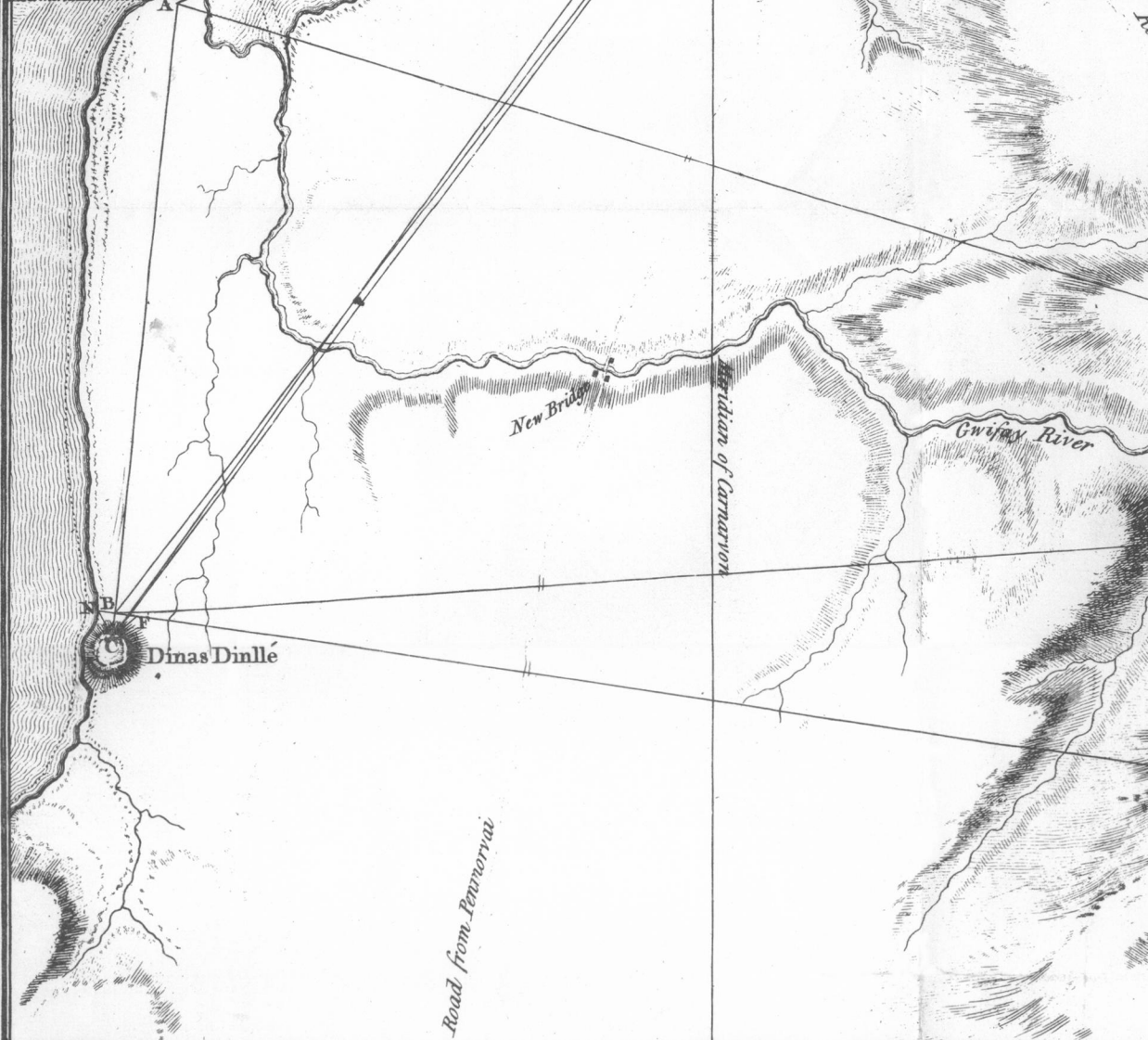
made use of for obtaining
the Geometrical Distance and Altitude
of SNOWDON and MOEL EILIO
with respect to the Sea at
CARNARVON.
Aug. 1775.



Scale of Feet.
1000 500 0 1000 2000 3000 4000 5000 6000

IONS.

Sides	Relative Heights			Relative Heights		
Feet.			Feet.			Feet.
DE. 29319.6	For the	S above B Trigonometrically	3493.2	For the Altitude of Moel Eilio above D, and	E above D Trig.	2183.8
		Curvature & Refraction	62.3		Curvature & Refraction	16.3
		Height of the Instrument	4.6		Instrument	4.6
		S above B	3560.1		E above D	2204.7
		C above B Trig.	97.3		D above Carnarvon Quay	166.3



GE O

The Base AB, situated on a perfectly level Plain, was measured twice in contrary directions, between the Barracks of Abermenai and the bottom of Dinas Dinlle, an ancient British Fortification, on the Sea Shore. The length of the Iron Chain made use of on this occasion, was ascertained by means of accurate Deal Rods, applied to it every Morning & Evening, before and after the operation of the Field. The two measurements agreed to within less than a Foot, and made the length of the Base — 14076F. This Base AB, was afterwards prolonged to C, the Top of the Dinas by means of the side Base BF 411.7 feet. Thus the distance BC, being 482.2 feet; the total Base AC amounts to 14558.2 feet.

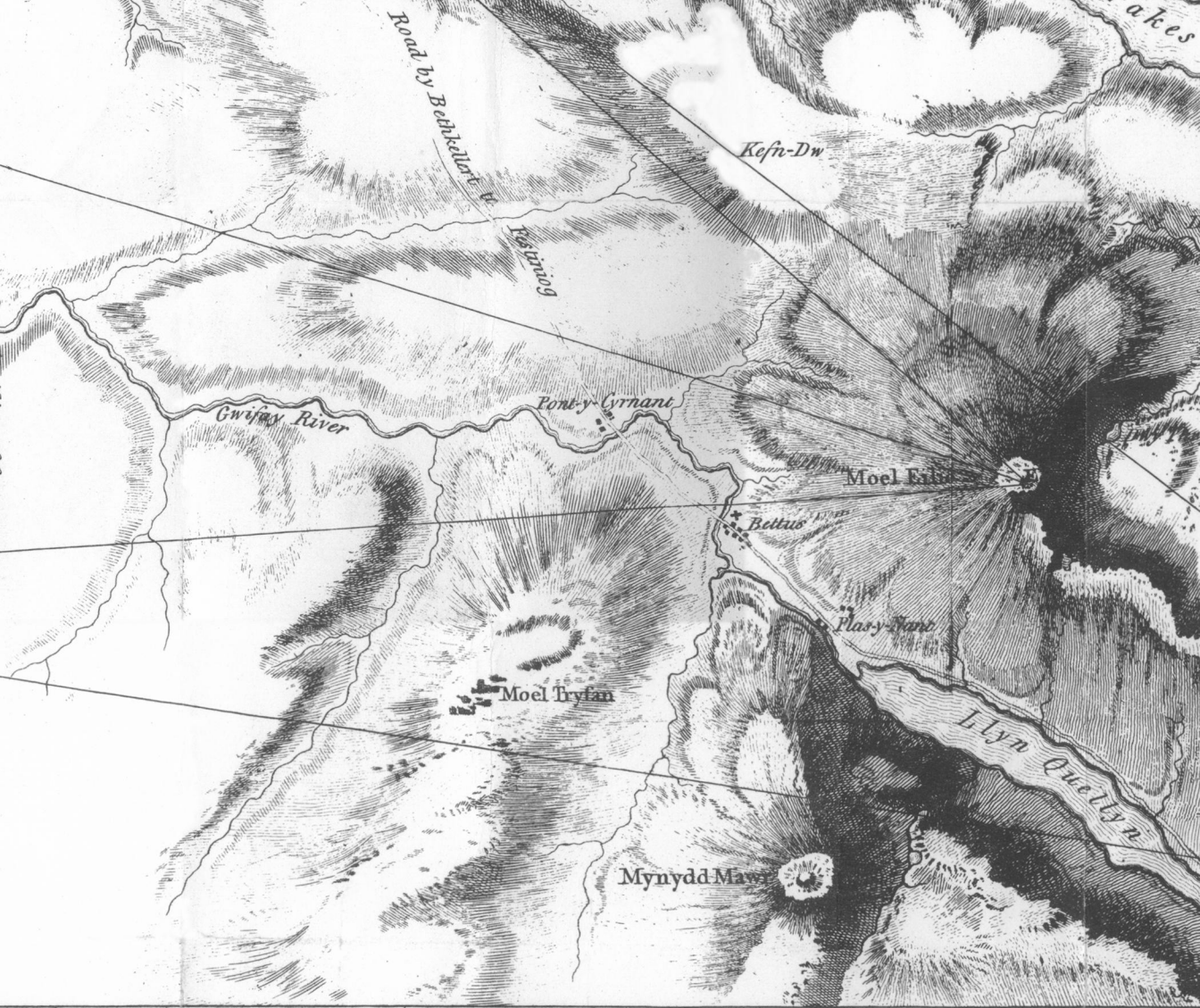
N, High Watermark Neap Tide. D, a small Eminence called the Digod, T, the Toot Hill of Carnarvon. S, The Peak of Snowdon. E, A Cairn of Stones on Moel Eilio.

The Latitude of Carnarvon was found to be $53^{\circ} 9' 47''$; and the Variation of the Needle, by two Azimuths of the Sun, taken on the 13th of Aug^r at 2.2. and 3.12 P.M. 21.18.30 westerly.

The Height of Moel Eilio above Carnarvon Quay 2371 Feet, resulting from the simplest operation on the Digod, the nearest point to the Hill, is to be preferred to that deduced from the Angles of Elevation taken from A.

Triangles.		Angles		Sides
				Feet.
CBF and CBN for the prolongation of the Base B C, and distance of N from C.	Obj ^d	CBF	$84^{\circ} 10' 40''$	BC...482.2
	Hence	BCF	$42^{\circ} 55' 25''$	
	Obs ^d	BFC	$52^{\circ} 53' 55''$	NC...612.5
		NBC	$98^{\circ} 46' 50''$	
		BCN	$30^{\circ} 8' 20''$	
ACD and DBC, for the distance of D from AB and C; and for the Angles CBD and BDC.		CNB	$51^{\circ} 4' 50''$	AD...17169.7
	Obs ^d	DAC	$123^{\circ} 17' 50''$	
		ADC	$25^{\circ} 48' 30''$	CD...27949.7
	Cont ^d	ACD	$30^{\circ} 53' 40''$	
		DCB	$30^{\circ} 53' 40''$	BC...482.2
DSB for the distance of Snowdon from B and D.		CBD	$148^{\circ} 35' 24''$	
		BDC	$0^{\circ} 30' 56''$	BD...27537.4
	Obs ^d	ABS	$92^{\circ} 36' 15''$	
		ABD	$20^{\circ} 24' 36''$	BS...57355.2
		DBS	$61^{\circ} 11' 39''$	
	Obs ^d	SDC	$89^{\circ} 35' 50''$	DS...50258.3
		+ CDB	$0^{\circ} 30' 56''$	
		SDN	$90^{\circ} 6' 48''$	
	Hence	DSB	$28^{\circ} 41' 35''$	

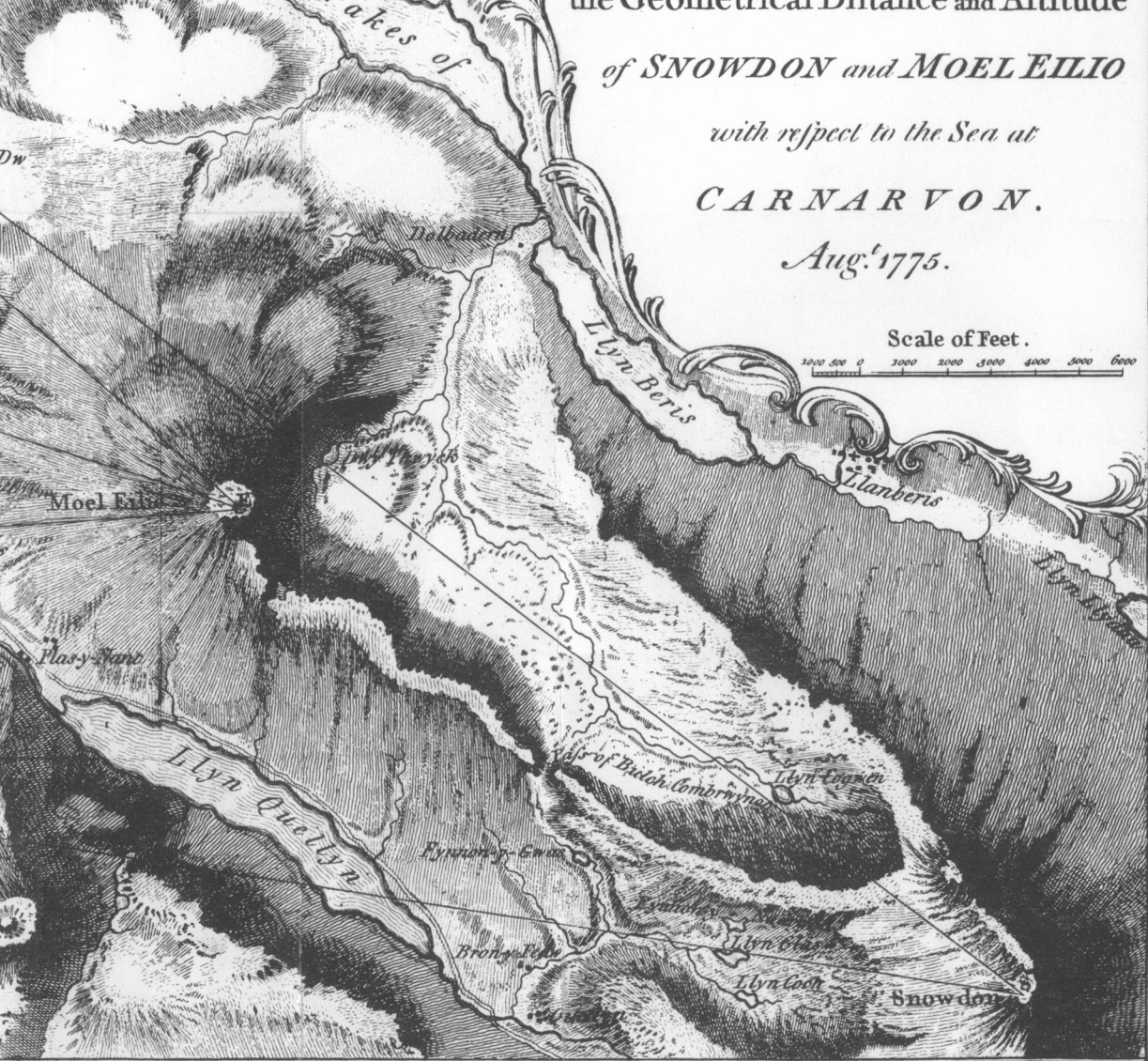
NB. The time not admitting of any actual Survey of the to be considered as a slight Sketch intended merely to convey



GEOMETRICAL OPERATIONS.

Angles.	Angles			Sides	Triangles	Angles			Sides	Relative Heights				
				Feet.					Feet.					
and CBN prolong- of the Base distance from C.	Obs. ^d Hence	CBF	84. 10. 40	BC... 482.2	DEB and DAE, For the distance of Moel Eiddaw from D and A.	Obs. ^d + =	EBA	79. 49. 10	DE... 29319.6	For the Altitude of Snowdon above B and N	S above B Trig Curvature of R Height of the			
		BCF	42. 55. 25				—	ABD				31. 24. 36	C above B C above B Trig Instrument C above B C above N Trig Instrument C above N Hence Babove Snowdon above	
		BFC	52. 53. 55					=				DBE		48. 24. 34
		NBC	98. 46. 50					+ CDB				EDC		86. 27. 5
	Obs. ^d	BCN	30. 8. 20	NC... 612.5			EDB	86. 58. 1						
and DBC, distance of AB and C; the Angles and BDC.	Obs. ^d Cont. ^d	CNB	51. 4. 50	AD... 17169.7 CD... 27949.7	CAT, for the distance of the Foot Hill from A.	Cont. ^d Obs. ^d	DEB	44. 37. 25	AE... 39190.2					
		DAC	123. 17. 50					ADE				113. 15. 55	S above D Trig Curvature of R Instrument S above D D above North Carnarvon Owe Vertical distance of	
		ADC	25. 48. 30					DAE				43. 40. 10½		
		ACD	30. 53. 40					DEA				23. 55. 14½		
	Cont. ^d	DCB	30. 53. 40	BC... 482.2			CAT	122. 9. 17	AT... 15430					
		CBD	148. 35. 24	BD... 27537.4		Obs. ^d	ACT	29. 56. 45				Snowdon above		
		BDC	0. 30. 56					ATC					27. 53. 53	
	Obs. ^d	ABS	92. 36. 15					—					C	11. 24. 37
	—	ABD	31. 24. 36						From... B	—	S	3. 29. 7	For the Altitude of Snowdon above D and the Sea at Carnarvon	
	=	DBS	61. 11. 30	BS... 57355.2	Angles of Elevation and Depression	From... C Dep	—	N	10. 34. 23					
	Obs. ^d	SDC	89. 36. 50	DS... 50258.3		From... D	—	S	3. 47. 54					
	+	CDB	0. 30. 56				From... A	—	E	4. 15. 35				
	—	SDB	90. 6. 48						E	3. 24. 17				
Hence	DSB	28. 41. 35						T	0. 39. 47					

The time not admitting of any actual Survey of the Environs of Carnarvon & Snowdon to be made; the Plan is only considered as a slight Sketch intended merely to convey a general Idea of the nature of the Country where the Triangles were situated.



ONS.

Sides	Relative Heights	Relative Heights
Feet.		
DE. 29319.6	<div> <p><i>For the Altitude of Snowdon above B and N</i></p> <p>S above B Trigonometrically 3493.2 Curvature & Refraction 62.3 Height of the Instrument 4.6 S above B 3560.1 C above B Trig. 97.3 Instrument 4.6 C above B 101.9 C above N Trig. 114.3 Instrument 4.6 C above N 109.7 Hence B above N 7.8 Snowdon above the Sea at N 3567.9</p> </div>	<div> <p><i>For the Altitude of Moel Eilio above D, and the Sea at Carnarvon.</i></p> <p>E above D Trig. 2183.8 Curvature & Refraction 16.3 Instrument 4.6 E above D 2204.7 D above Carnarvon Quay 166.3 Vertical distance of Barom. 2371.0 Quay above Neap Tide 13. Moel Eilio above the Sea 2384.</p> </div>
AE. 39190.2	<div> <p><i>For the Altitude of Snowdon above D and the Sea at Carnarvon</i></p> <p>S above D Trig. 3336.7 Curvature & Refraction 47.3 Instrument 4.6 S above D 3389.1 D above North Angle of Carnarvon Quay by Levell. 166.3 Vertical distance of the Barometers 3555.4 Quay above High Water N. Tide 13. Snowdon above the Sea 3568.4</p> </div>	<div> <p><i>For the Altitude of Moel Eilio above A, and the Sea at Carnarvon.</i></p> <p>T above A Trig. 178.6 Curvature & Refraction 4.5 Instrument 4.6 T above A 187.7 T above Carnarvon Quay by Levelling 186.5 Quay above A 1.2 Hence the Vertical distance of the Barometers 2364.1 Moel Eilio above Neap Tide 2377.1</p> </div>
AT. 15430		

the Plan is only where the Triangles were situated.